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Draft Test Report: A Performance Test on a Spray Dryer, Fabric Filter, and Wet Scrubber System

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The EPA's Office of Solid Waste (OSW) is currently developing regulations to control emissions of products of incomplete combustion, particulate matter and toxic metals from hazardous waste incinerators. Emissions data to support these regulations was collected and testing was conducted on a toxics substances control waste incinerator between 4/25-27/89. EPA's objectives were to collect particulate and metals removal efficiency and emissions data for the combined spray dryer and baghouse system and the total air pollution control system; characterize the fate of waste feed metals through the incineration and air pollution control systems; and evaluate the potential use of a surrogate metal "soup" as a means of assessing control efficiencies and establishing allowable waste feed concentrations for toxic metals.

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DRAFT TEST REPORT

A PERFORMANCE TEST

ON A

SPRAY DRYER, FABRIC FILTER,

AND WET SCRUBBER SYSTEM

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1.0 INTRODUCTION

The Environmental Protection Agency's (EPA) Office of Solid Waste (OSW) is currently developing regulations to control emissions of products of incomplete combustion, particulate matter and toxic metals from hazardous waste incinerators. Radian Corporation, under subcontract to Versar, Inc., was contracted by the EPA to collect emissions data to support these regulations. The testing was conducted on a Toxics Substances Control (TSCA) waste incinerator operated by Aptus Environmental Services in Coffeyville, Kansas. The test program took place between April 25 and April 27, 1989.

The test program was a cooperative effort between the OSW and Aptus. The EPA provided resources for the flue gas sampling and analysis and Aptus provided resources for feed spike materials and for the collection and analysis of incinerator feed and ash samples.

The incineration system at the Coffeyville facility consisted of a rotary kiln and afterburner followed by a series of air pollution control devices. Flue gases from the afterburner entered the following control systems in series: a spray dryer/baghouse system, a saturator, two cross-flow acid gas absorbers, and two ionizing wet scrubbers.

EPA's objectives for the test program were to:

- Collect particulate and metals removal efficiency and emissions data for the combined spray dryer and baghouse system and the total air pollution control system;
- Characterize the fate of waste feed metals through the incineration and air pollution control systems; and
- Evaluate the potential use of a surrogate metal "soup" as a means of assessing control efficiencies and establishing allowable waste feed concentrations for toxic metals.

Toxic and surrogate metals of interest to this program included: antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, copper, lead, magnesium, manganese, mercury, nickel, selenium, silver, strontium, tellurium, thallium, and zinc. Flue gas sampling for metals and particulate was performed at the afterburner outlet, the baghouse outlet and the stack. Waste feed materials, kiln ash, baghouse ash, and brine solutions were also sampled and analyzed for metals content. Details concerning test conditions and the quantities of toxic and surrogate metals spiked into the waste feed are discussed in Section 2.0.

In addition to meeting the above EPA objectives, the test program was designed to serve as a trial burn for Aptus to obtain 1) a new Toxic Substances Control Act (TSCA) permit following modifications to the existing air pollution control system and 2) a Solid Waste permit for the disposal of selected wastes not regulated under either the Resource Conservation and Recovery act (RCRA) or TSCA. The modification made to the control system was the addition of the spray dryer and baghouse.

The test program was designed and executed with an emphasis on completeness and quality with a comprehensive quality assurance/quality control (QA/QC) program included as an integral part of the overall test program. The goal of the QA/QC effort was to ensure that the data collected are of known precision and accuracy and that the data are complete, representative and comparable.

2.0 PROCESS DESCRIPTION

This section provides a description of the incineration and air pollution control system tested at the Aptus facility. The process description is provided in two levels of detail. A brief description is provided in Section 2.1 and a more detailed description is provided in Section 2.2.

2.1 The Aptus System

The Aptus incinerator in Coffeyville, Kansas consists of a horizontal slagging rotary kiln followed by a vertical afterburner. The associated air pollution control equipment consists of several control devices in series: a spray dryer/baghouse system, a saturator, a wet scrubber, a wet absorber and two ionizing wet scrubbers (IWS). A flow diagram of the incinerator and air pollution control devices is illustrated in Figure 2-1.

2.1.1 Incineration System

A variety of wastes may be fed into the incinerator. These include: PCB liquids, shredded PCB-containing capacitors, contaminated soil, aqueous wastes and debris. Solid wastes and containerized wastes are fed to the kiln through the solids feed chute. Primary ignition and combustion for the kiln is provided by a combination burner which burns PCB liquids or auxiliary fuels (natural gas or fuel oil). The front wall of the kiln also incorporates a direct-burn waste atomizing nozzle and a sludge lance. Aqueous wastes and blended combustible liquid wastes can be mixed and introduced into the kiln through the direct burn waste atomizing nozzle. The sludge lance can be used to introduce sludge suspended wastes into the kiln. (The sludge lance was not permitted by the time of this test.)

The afterburner chamber is equipped with three possible sources of waste injection: a combination burner, a liquid waste burner, and an aqueous waste atomizing nozzle. The afterburner may be fired with PCB liquids or auxiliary fuel.

The incinerator kiln operates in a temperature range of approximately 1,600-1,900°F. The afterburner typically operates at 2,200°F. Total design heat release rate for the incinerator is 61.9 MMBtu/hr. Gas in the afterburner has a residence time in excess of two seconds and flue gas exiting the afterburner passes through a hot duct which increases residence time at the afterburner temperature. The hot duct includes an emergency relief vent which can bypass the air pollution control system, if required. Typical system operating parameters are listed in Table 2-1.

2.1.2 Air Pollution Control System

Flue gas from the hot duct enters the spray dryer where it is contacted with a sodium carbonate brine solution so that the gas temperature is lowered from 2,200°F to approximately 460°F. The primary purpose of the spray dryer is to dry the brine solution generated in the downstream wet scrubber, wet absorber and ionizing wet scrubbers. A secondary result of the spray dryer is to improve particulate control and remove a portion of the acid gases present.

As the flue gas is quenched in the spray dryer, water in the brine solution is evaporated and the salts present in the brine dry to form solid particles. Some of the salt or ash solids drop out of the flue gas at the base of the spray dryer; however, most of the ash is collected and removed in the baghouse. Flue gas particulates that are not captured in the baghouse consisting primarily of submicron particles pass to the wet scrubbing portion of the system described below.

Flue gas leaving the baghouse enters a saturator, where the gas temperature is adiabatically lowered to approximately 170°F. Of the HCl remaining in the baghouse exit flue gas, the majority is removed in an absorber and scrubber which follow the saturator in series. The scrubbing solution is fed to these units from "neutralization tanks" where soda ash is added to the brine solution to control pH.

Gas from the absorber and scrubber enters the two IWS units which form a two-stage fractional collection device for the remaining micron- and submicron-sized particles. Particles entering the IWS are electrostatically charged in the high voltage ionizer section and removed in the subsequent packed scrubbing section by inertial impaction and by electrostatic charge force attraction with the packing material. Scrubbed particles are continuously removed by spraying the packing with liquid. The IWS units also provide larger particulate removal during start-up, when the baghouse is bypassed. Gas exiting the IWS system is at 145°F and enters the induced draft (ID) fan. Scrubbed flue gas is vented to the atmosphere through a 110-foot stack.

2.1.3 Incinerator Slag and Ash

Slag and ash from the kiln and afterburner discharge into a bin containing water to quench them and reduce their temperature to 180°F. The quenched slag and ash are drawn from the bottom of the bin and conveyed to an ore bin. The bin and conveyor system is referred to as a wet deslagger. Spray dryer solids and baghouse ash are combined to form one dry waste stream which is conveyed to 2-cubic yard tote sacks via screw augers. There are no liquid discharges from the wet scrubbing systems. All of the make up water and soda ash which feed the three brine systems are recycled to Brine Solution I which is fed to the spray dryer.

2.2 Detailed Process Description

2.2.1 Incineration Process

The incineration system consists of the combustion air, auxiliary fuel, and waste feed systems; the rotary kiln; the afterburner; and the slag removal system. Each of these subsystems is discussed in the sections which follow.

2.2.1.1 Combustion Air

A combustion air blower provides air to the burners and burner windowbox areas to ensure controlled combustion for both the kiln and afterburners. Small amounts of in-leakage air occur since the kiln is operated under negative pressure provided by the induced draft fan at the end of the flue gas cleaning train.

2.2.1.2 Auxiliary Fuel System

The auxiliary fuel system is used to control the combustion temperatures in the kiln and afterburner and to maintain flame stability in the burners. Auxiliary fuel is used for start up and shut down of the system. Natural gas is primary fuel with No. 2 fuel oil as backup. The fuels are injected through a combination burner at the kiln front wall and two combination burners installed in the walls near the afterburner inlet. Fuel flow control is fully automated to provide optimum operations and constant temperature control.

2.2.1.3 Liquid Waste

Blended liquid waste can be injected to both the kiln and the afterburner. The liquid blend is made up in blend tanks in the bulk liquid storage area. Flow of the waste to each nozzle is controlled and metered to ensure proper firing. There is also an aqueous waste spray nozzle in the afterburner. Aqueous waste can be fed at a rate of up to 6 gpm.

2.2.1.4 Sludges

Pumpable sludges may be fed into the front wall of the kiln through a sludge lance. The sludge lance was not permitted for operation during this test.

2.2.1.5 Solids

Solids are fed from drums at a rate of approximately 16 drums per hour. The solids feed system consists of:

- Staging area,
- Solids shredder,
- Conveyor,
- Elevator, and
- Feed shoot/inlet isolation chamber system.

Capacitors are shredded into 55-gallon drums and drums filled with other capacitors and other solids are staged on the conveyor. The conveyor feeds drummed material to an elevator which raises the drums to the feed shoot inlet where they are emptied automatically. A 4-minute feed cycle was typical throughout the tests. The dumped feed enters the vertical shoot entry chamber and the top chamber doors open admitting a feed charge. The top doors are closed and the bottom doors opened, permitting the feed charge to enter the kiln. Empty drums are returned to the drum staging area and reused.

2.2.1.6 Rotary Kiln

The rotary kiln is a horizontal unit which is operated in a slagging mode with operating temperatures between 1,700 and 1,900°F. The unit is slightly inclined and rotates so that a solids retention time of 30 to 45 minutes is maintained. Slag discharges from the end of the kiln into a quench tank where the slag is removed by a drag conveyor which discharges into an ore bin. The kiln provides about 0.8 seconds residence time for gases and entrained particulates. The combustion products from the kiln enter the bottom of the vertical afterburner.

2.2.1.7 Afterburner

The afterburner is operated at 2,200°F and provides in excess of two seconds residence time for the combustion products by virtue of its 13-foot diameter, 35-foot high, cylindrical volume. The afterburner waste and fuel ports are located 20 feet from the top and are fired across the flow of the combustion gases. This firing provides good mixing and contact of the flames and inlet gases. The outlet combustion products flow into a hot duct which has an emergency relief vent mounted at its top. The gas stream is turned and then flows down through the duct into the spray dryer, the first unit of the air pollution train. The design heat release for this system (combined kiln and afterburner) is 61.9 MMBtu/hr.

2.2.2 Air Pollution Control System

The air pollution control system consists of a spray dryer and baghouse system followed by a wet scrubbing train. Three separate brine solution systems (Brine Solutions I, II and III) independently feed the spray dryer and five remaining units in the train. The remaining units consist of a saturator, an absorber, a scrubber, and two ionizing wet scrubbers (IWS) in series. The spray dryer and baghouse system was installed and made operational in early April 1989.

2.2.2.1 Spray Dryer

The spray dryer provides flue gas cooling, condensation and agglomeration of the metals and particulate in the combustion gases, and secondarily provides acid gas scrubbing. To accomplish these functions, the combustion products flow down through the unit and are spray cooled with a soda ash acid neutralization solution (Brine Solution I). The brine feed rate to the spray dryer is approximately 80 gpm. The gas stream is cooled to about 460°F by evaporative cooling. The temperature drop causes materials in the flue gases to condense and agglomerate while the gas stream remains above the dew point. The soda ash in the solution forms a dry powder along with any salts created by reaction with the acid vapors in the flue gas. These solids are partially removed from the bottom of the spray dryer through a rotary valve which discharges to the fly ash conveyor. This conveyor (screw auger) combines these solids with the ash from the baghouse and the mixed stream is loaded into tote bags for off-site disposal. A full bag is nominally 3 feet square by 6 feet high (two cubic yards) and can hold about a ton of fly ash. The solids-laden gas stream exits the spray dryer and then enters the baghouse.

2.2.2.2 Baghouse

The baghouse serves as the primary particulate control device in the system. The baghouse is a four chambered unit with vertically mounted filter sacks in each chamber. The filter cake deposited on the cloth not only provides filtration of particulates but also provides some amount of soda ash/acid gas reaction contact time in a dry environment. Pulse jet air is used to remove the filtered solids (fly ash) which build up on the cloth and the solids fall to the bottom of each collector chamber where they are discharged through rotary valve air locks to the fly ash conveyor. The solids combine with spray dryer solids and are disposed of as discussed above. The gases pass through the bags and are ducted to the inlet of the saturator.

2.2.2.3 Spray Saturator

The spray saturator cools the gases to the saturation temperature of approximately 170°F with Brine Solution I. The saturator liquids that collect in the bottom are recirculated, and any excess drains into the rundown sump. Fresh Brine Solution I is also sprayed into the saturator in addition to the internal recirculation brine. The fresh brine feed rate is approximately 119 gpm. Materials in the gaseous phase of the inlet stream (e.g., mercury) at $460^{\circ}F$ are condensed at the $170^{\circ}F$ outlet temperature of the saturator. This enables the liquid and solids formed to be removed by the cross flow scrubbing units down stream of the saturator.

2.2.2.4 Cross Flow Absorber

The cross flow absorber receives the saturated (wet) vapor steam from the saturator and most of the acid gases and additional solids are removed by Brine Solution I contacting the gas stream as it passes through the wetted bed packing. The brine solution collects in the bottom of the absorber and discharge to the rundown sump. Note that Brine Solution I is the feed to the spray dryer, the saturator, and the absorber. The brine solution is fed to this absorber at a rate of approximately 2,140 gpm.

2.2.2.5 Cross Flow Scrubber

The cross flow scrubber further treats the gases with Recirculating Brine Solution II. This stage continues the removal of acid gases including control of SO_2. The scrubber, like the absorber, contacts the brine solution with the flue gases on a brine wetted packed bed. Solution from the scrubber outlet flows to the bottom of the first IWS unit, Unit 1. Brine from that IWS unit is recirculated to the inlet of both the scrubber and back to the inlet of that IWS Unit 1. Excess solution from this circuit overflows from the bottom of IWS 1 and drains to the rundown sump where overflow brine solutions from the saturator and the absorber are also collected. The gas stream that leaves the scrubber passes into IWS 1. The total pressure drop across the absorber and scrubber combined is 2.8 inches W.C.

2.2.2.6 IWS 1

The IWS 1 is the first of two cross flow IWS units. First, the gases pass through the charging zone which is wetted with Brine Solution III.

The charged droplets and particulates enter the packed/charged scrubber section which is wetted with recirculated Brine Solution II. (Solution II is taken from the bottom of this IWS unit.) This solution in conjunction with the electrostatic charge, enhances submicron particulate and acid gas removal. Finally, the gases pass into the last IWS unit, Unit 2.

2.2.2.7 Final IWS System

This final IWS system is a polishing unit that removes trace amounts of contaminants from the flue gases prior to discharge to the atmosphere through the stack. Cooling tower blowdown water is used as the make up to the particle charging zone. Charged droplets and particulates leave the charging section and enter the packed/charged brine wetted bed. Brine Solution III and make up water that collect in the IWS bottom are recirculated back to the bed of this unit and the charging zone of the first IWS unit (as described in the paragraph above). The pressure drop across the two IWS units is 2.8 inches W.C. Gas exiting IWS 2 is at 145°F. Treated gases exit IWS 2 and are drawn into the inlet of the induced draft fan.

2.3.3 Brine Makeup and Circulation

The brine systems have been designed so that there is no net discharge of liquid from them. All the water that is added to the brine system is evaporated. Small amount of water are emitted in the flue gas exiting the stack. The three brine circulating systems have been partially described. This section will review their flow and function as well as the makeup system.

Brine Circuit I (Figure 2-1, red) has five major components; the soda ash make up system, the rundown sump and pump, two well stirred neutralization tanks, a brine cooling heat exchanger, and the cooling tower. The two feeds making up Brine Solution I are liquid soda ash and rundown from Brine Solution II (Figure 2-1, blue). The soda ash feed solution is made from powered soda ash and a slipstream from the Brine I circuit. The powdered soda ash is metered from its bulk storage bin directly into a well stirred mix tank. This feed solution is pumped directly to the rundown sump where it combines with the discharges of the saturator, the absorber, and IWS 1 (which is Brine Solution II). The blended solution from the sump is pumped to the first neutralization tank. This well agitated vessel allows time for the soda ash to neutralize the acid absorbed in the brine solution. The solution overflows from this tank into the second neutralization tank. Like the first, this vessel is well agitated and provides more reaction time. Neutralized Brine Solution I is pumped from the bottom of the tank to the spray dryer, the saturator, and the absorber. Brine Solution I that goes to the saturator and absorber, however, is first cooled in a shell and tube heat exchanger using water from the cooling tower. Plant water is used as the make up to the cooling tower and blowdown water from the cooling tower is the feed to the Brine Circuit III (Figure 2-1, green).

Brine Circuit II is a recirculating system for the scrubber and IWS 1 units. Brine solution in the circuit has no soda ash make up and thus its only sources of brine are the droplets contained in the inlet gases from the absorber and rundown from Brine Circuit III Brine Solution II is circulated from the bottom of IWS 1 to the liquid inlet of both IWS 1 and the scrubber. As previously described, the solution from the scrubber flows into the bottom of IWS 1. Excess Brine Solution II flows to the rundown sump where it becomes one of the feeds to Brine Solution I.

Brine Solution III is circulated from the bottom of IWS 2 back to its charged packed bed. A slip stream from the recirculation line is fed to IWS 1. That slip stream is the liquid make up to Brine Circuit II described above. Brine Circuit III receives its make up water from two sources; a make water stream from the cooling tower sump and the droplets of moisture contained in the inlet gases to IWS 2.

Thus, inlet water to the entire APCD system flows countercurrent to the vapor flow through the APCD system. Make up water enters IWS 2, the last unit in the APCD train. As a result, Brine Solution III is the most dilute brine solution. A slip stream of Brine Solution III is the make up to the brine solution in IWS 1, Brine Solution II. Brine Solution II has a moderate or median concentration of brine and contaminants. And finally, a rundown stream from IWS 1 (Brine Solution II) is the make up to the rundown sump where it is the feed to Brine Solution I, the most concentrated brine solution. Thus, the soda ash and contaminants in the brine solutions flow countercurrent to the gas flow and are finally purged from the brine system in the spray dryer, the first unit in the flue gas train.

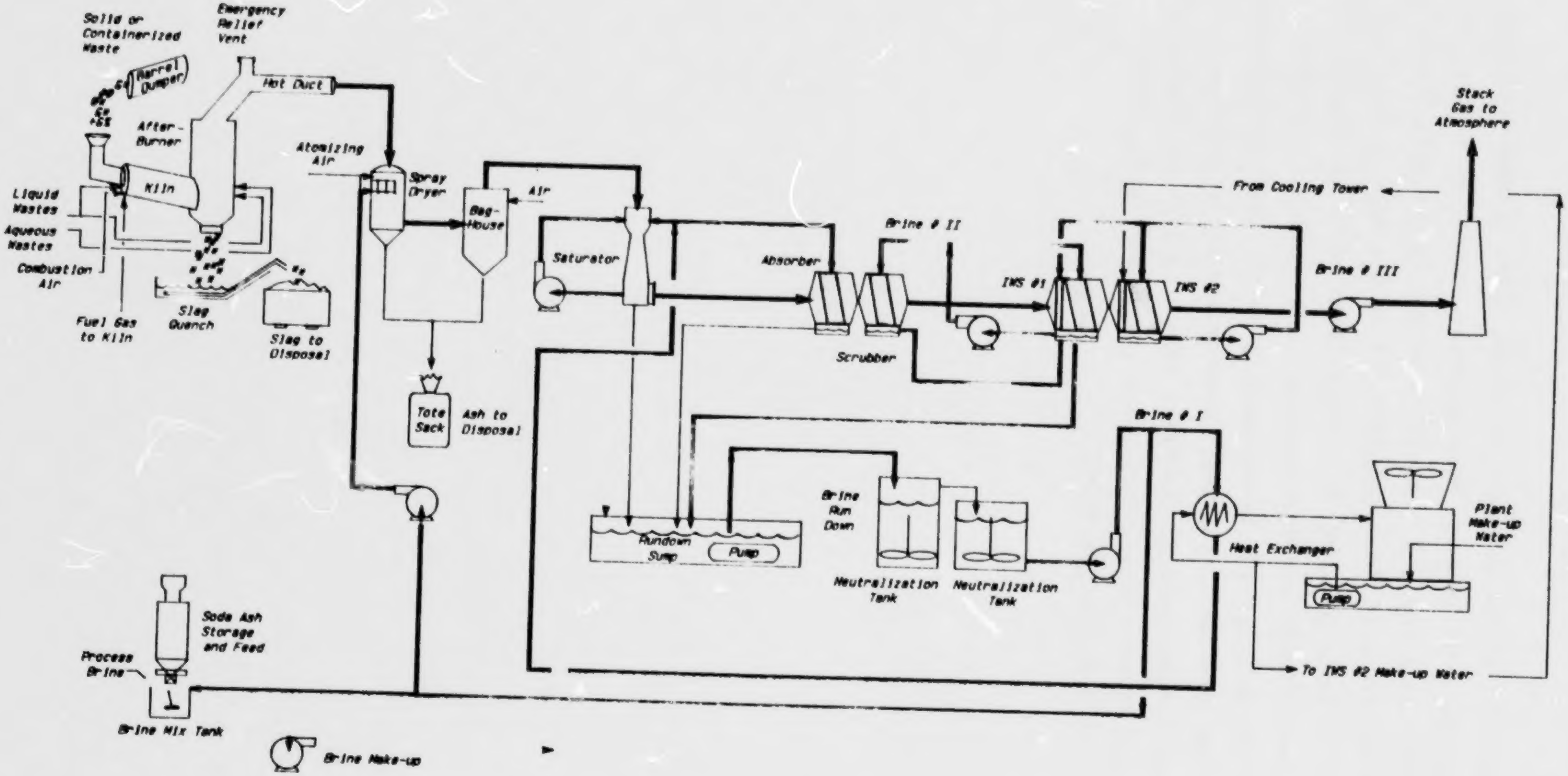
Solid or Containerized Waste
Barrel Dumper
Emergency Relief Vent
Hot Duct
After-Burner
Kiln
Liquid Wastes
Aqueous Wastes
Combustion Air
Fuel Gas to Kiln
Slag Quench
Slag to Disposal
Atomizing Air
Spray Dryer
Bag-House
Air
Tote Sack
Ash to Disposal
Saturator
Absorber
Scrubber
Brine # II
IWS #1
IWS #2
From Cooling Tower
Brine # III
Stack Gas to Atmosphere
Brine # I
Rundown Sump
Pump
Brine Run Down
Neutralization Tank
Neutralization Tank
Heat Exchanger
Plant Make-up Water
Pump
To IWS #2 Make-up Water
Soda Ash Storage and Feed
Process Brine
Brine Mix Tank
Brine Make-up

Figure 2-1. APTUS Incineration System
Coffeyville, Kansas

TABLE 2-1. INCINERATION SYSTEM OPERATIONAL PARAMETERS

Waste Feeds	
Solid Waste	1,500-3,900 lbs/hr
Combustible Liquid Waste	2,100-4,300 lbs/hr
Aqueous Waste	400-2,000 lbs/hr
Flow Rates	
Afterburner Exit	20,000 scfm
Baghouse Exit	34,300 scfm
Stack	24,100 scfm
Stack	34,100 acfm
Process Temperatures	
Kiln	1,600-1,900°F
Afterburner	2,200°F
Spray Dryer Exit	460°F
Baghouse Exit	450°F
Saturator Exit	170°F
Wet Scrubber Exit	146°F
IWS Exit	145°F
Stack	145°F
TOTAL Heat Input:	61.9 MMBTU/hr

3.0 PROCESS OPERATION

This section provides a description of the feed conditions and incineration and air pollution control system operation during this program. The test program was conducted under two feed conditions while essentially maintaining the incineration and air pollution control system operating set points at constant levels. The feed conditions are described in Section 3.1 and the incineration and air pollution control systems operating data are presented and evaluated in Section 3.2.

3.1 Feed Conditions

Tests of three runs (triplicate tests) were conducted at two different feed conditions. Both test conditions were established so that elevated concentrations of metals, and polychlorinated biphenyls (PCB) were present in the feed matrix. The five feed streams that made up the feed matrix were:

- Contaminated soil (PCBs), fed from drums to the kiln;
- Contaminated soil (PCBs) and latex paint, fed from drums to the kiln;
- Debris (largely paint filters), fed from drums to the kiln;
- Blended liquids containing PCBs atomized into the kiln and afterburner; and
- Aqueous waste with negligible metals content atomized into the afterburner.

The feed rates for each stream are summarized in Table 3-1. The feed blend for each test condition was developed so as to maximize the thermal heat input as well as the metals content. Conditions were selected to yield two different chlorine loadings to facilitate the evaluation of the effect of chlorine on metals partitioning and removal. A first condition was selected with a waste feed chlorine content of approximately 10% (this yielded approximately 0.5% HCl in the flue gas). This condition is representative of operation under RCRA with chlorinated spent solvent and chlorinated organic wastes as feed materials. A second condition was selected with a waste feed of approximately 20% chlorine (this yielded approximately 2% HCl in the flue gas). This condition is representative of operation under RCRA and TSCA with chlorinated spent solvent and chlorinated organic wastes as well as PCB-containing wastes as feed materials. Secondarily, water content, ash content, and heating value were used to adjust the feed blend to operate within the constraints of the existing TSCA permit. The water, ash, chlorine, and PCB content as well as heating value of each waste stream are shown in Table 3-2.

The metals content of the feed streams (excluding the aqueous stream) are listed for each test condition in Tables 3-3 and 3-4. To increase the metals content of the feed matrix, a pre-weighed amount of material was added to each drum. The surrogate metals mixture included:

- Bismuth, as bismuth nitrate;
- Magnesium, as contained in lime;
- Mercury, as pure metal in a glass vial;
- Strontium, as strontium carbonate;

Caustic slag from a primary zinc smelter, containing appreciable quantities of lead, arsenic, zinc, and antimony, was added to each drum of solids feed for Condition 1, Runs 1, 2, and 3. Tellurium slag from the processing of selenium and tellurium, containing tellurium, antimony, lead, nickel, and zinc, was added to each drum of solids feed for Condition 2, Runs 4, 5, and 6.

Three of these metals are components of a metals surrogate mixture[1] (bismuth, magnesium, and strontium) and were added in solid form. Pre-measured amounts of bismuth nitrate ($Bi(NO_3)_3 \cdot 5H_2O$), magnesium carbonate

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[1] Barton, R.G., W.D. Clark, and W.R. Seeker, Engineering Analysis of Hazardous Waste Thermal Destruction, Draft Topical Report: Surrogate Metals Mixture, EPA Contract 68-03-3365, October 1988.

($Mg(CO_3)_2) \cdot 6H_2O$), and strontium carbonate ($Sr(CO_3)_2) \cdot 4H_2O$) were placed in sacks and subsequently placed in each drum fed to the kiln. The fourth component of the surrogate mixture, copper, was present at sufficient concentrations in the shredded capacitors.

The analytical results for the soil, debris, and paint were from grab samples of each drum of material charged in a run. These analyses were averaged for each run for each metal. The metal contents for the liquid blend and all the spikes were based on an individual grab sample, while the capacitors metals content was based on prior analysis of the units. The feed rate of each metal in pounds per hour was calculated from the concentration and feed rate of the stream. These rate results are listed in Tables 3-5 and 3-6. For Condition 1 and Condition 2, the metals feed rates are similar with the following exceptions:

- Condition 1 has two to three times the feed rate of chromium, copper, lead, and zinc because Condition 1 had 2.5 times the capacitor feed rate which is the major source for these metals.
- The arsenic level in Condition 1 is two orders of magnitude higher than for Condition 2 due to the addition of the caustic slag in Condition 1.
- The beryllium level in Condition 1 is substantially higher than in Condition 2 due to its presence in the soil.
- The tellurium level in Condition 2 is 50 times higher than for Condition 1 due to the addition of the tellurium slag during Condition 2.

The PCBs fed to the incinerator were contained in the PCB-contaminated soil, capacitors, and blended PCB liquid wastes. The capacitor and liquid wastes constituted the major source of the PCBs for the tests. The level of PCB added was established to provide adequate HCl flue gas concentrations. A high HCl concentration at the air pollution control device (APCD) inlet was needed to match the facility permit limits and determine the HCl removal efficiency. Test Condition 2 PCB addition rate was 1,900 pounds per hour, while Condition 1 was run at a rate of 700 pounds per hour.

3.2 Process Operating Conditions

The process control settings for both the incineration and air pollution control systems were similar for both test conditions and were not changed from run to run within a condition. The averages reported are based on hourly data readings with both averages and standard deviation reported. These data are reported for Conditions 1 and 2 in Tables 3-7 and 3-8, respectively. A summary for Conditions 1 and 2 and the entire test is presented in Table 3-9. Typically, the standard deviation ranged from less than 1% to 3% of the average. A standard deviation of this magnitude is indicative of low variation between the six runs. The hourly readings, taken off of continuous reading strip charts and/or recorders, are presented in Section B of the appendix. An engineer was present in the control room during all tests to monitor the system operating and alert the sampling crew at the onset of an upset or operational problem.

In summary, the kiln was operated at 1,700°F, while the afterburner temperature was maintained at 2,206°F. The spray dryer outlet temperature averaged 462°F, while the stack gases averaged 146°F. The oxygen content of the kiln fluctuated between an hourly average low of 3.9 and an hourly average high of 11.1 percent. The oxygen level exiting the stack averaged 8.3% for all six tests, while the carbon monoxide level was consistently running along the baseline of the strip chart indicating that good combustion conditions were maintained.

TABLE 3-1. SUMMARY OF WASTE FEED RATES

(Units - lbs/hr)

	Plan	Run 1	Run 2	Run 3	Plan	Run 1	Run 2	Run 3
Contaminated Soil	500	387	495	580	0	0	0	0
Contaminated Soil and Latex Paint	0	0	0	0	700	845	564	637
Capacitors	2,750	2,659	2,722	2,809	1,100	1,142	904	1,116
Debris	200	155	170	200	100	77	62	58
Surrogate Metals Mixture	45	42	44	47	45	47	38	42
Mercury	2	1.8	2.0	2.1	2	2.1	1.6	1.9
Caustic Slag	15	14	14.7	15.6	0	0	0	0
Tellurium Slag	0	0	0	0	7	7.9	6.0	7.1
Total Solids	3,512	3,259	3,448	3,654	1,954	2,121	1,576	1,862
PCB Liquid	3,222	2,123	3,059	2,115	4,200	4,146	4,250	4,272
Aqueous	1,000	1,410	1,990	848	1,000	1,778	1,773	1,760
Total Liquids	4,222	3,533	5,049	2,963	5,200	5,924	6,023	6,032
Total Feed	7,734	6,792	8,497	6,617	7,154	8,045	7,599	7,894
Total Chlorine in Feed	773	656	760	681	1,431	1,849	1,851	1,865
Percent Chlorine in Feed	10	9.7	8.9	10.3	20	23.0	24.4	23.6

TABLE 3-2. WASTE PROFILE

Waste	H_2O (%)	Ash (%)	Cl (%)	PCB (%)	Heat Value BTU/lb
Contaminated Soil	2.0	45	0.2	0.2	2,100
Capacitors	0	28	16.7	21.0	6,657
Debris	8	5	0.1	0	10,000
Latex Paint	48	11.5	0.2	0	2,640
Oil-Based Paint	3.6	11.7	0.2	0	14,700
Paint Filters	0	5.4	0	0	5,300
Aqueous	98	2	0	0	0
PCB Liquid Run 1	0	0.5	10.0	12	17,124
PCB Liquid Run 2	0	0.5	40.0	25	10,266

NOTE: All percents (%) are based on weight.

Table 3.3
Condition #1
Summary of Waste Metal Feed Concentrations

(parts per million by weight)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.01	0.10		< 0.005	190.32	1.82	0.62	2.89	
Arsenic (As)	2.37	< 0.06		9.330	94195.16	6.88	6.88	6.88	
Barium (Ba)	169.97	879.16		0.680	2.50	2.77	44565.82	3.71	
Beryllium (Be)	57.46	< 0.01		< 0.005	0.50	0.63	0.63	0.63	
Cadmium (Cd)	2.70	0.07		< 0.005	12.10	0.63	0.63	0.63	
Chromium (Cr)	90.29	8.09	18000 a	< 0.005	42.74	12156.16	161.54	2.08	
Copper (Cu)	419.56	4.50	9000 b	1.190	1471.77	1.88	15.34	1.88	
Mercury (Hg)	3.09	0.64		0.070	5.00	95.32	8.75	27.67	1000000
Manganese (Mn)	295.68	253.82		0.300	5.65	0.63	14.79	178.28	
Nickel (Ni)	13.21	2.19		< 0.010	183.07	1.25	1.25	1.25	
Lead (Pb)	51.34	15.87	12000	1.250	327512.90	5.00	48.55	5.00	
Antimony (Sb)	< 0.11	< 0.11	500	< 0.110	34468.55	13.75	56.38	13.75	
Selenium (Se)	< 0.05	0.06		< 0.050	79.84	6.25	6.25	6.25	
Thallium (Tl)	41.87	2.63		1.400	20.00	23.75	23.75	23.75	
Zinc (Zn)	276.73	423.61	1000.00	3.270	59285.48	3.13	148.08	24.05	
Bismuth (Bi)					125.00	392691.60	8870.89	1766.67	
Calcium (Ca)					704.84	9.84	592.71	439444.70	
Magnesium (Mg)					292.08	168.39	6134.55	3580.27	
Strontium (Sr)					2.50	32.10	473288.55	325.33	
Tellurium (Te)					642.97	5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since contribution is negligible

Table 3.4
Condition #2
Summary of Waste Metal Feed Concentrations

(parts per million by weight)

Parameter	Soil	Paint	Paint & Soil	Debris	Capacitors	Liquid Feed	Tellurium Spike	Bismuth Slag	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.01	0.06	< 0.01	0.11		< 0.005	16.44	1.82	0.62	2.89	
Arsenic (As)	8.95	0.06	< 0.05	0.08		2.860	1370.65	6.88	6.88	6.88	
Barium (Ba)	218.32	461.32	555.70	1713.33		0.770	2.50	2.77	44565.82	3.71	
Beryllium (Be)	0.73	< 0.02	< 0.01	0.01		< 0.005	0.50	0.63	0.63	0.63	
Cadmium (Cd)	2.55	1.04	0.70	0.13		< 0.005	33.07	0.63	0.63	0.63	
Chromium (Cr)	806.90	12.50	28.37	127.42	18000 a	0.590	7.63	12156.16	161.54	2.08	
Copper (Cu)	154.60	6.79	6.42	8.04	9000 b	0.630	5085.13	1.88	15.34	1.88	
Mercury (Hg)	1.24	19.14	15.52	0.89		< 0.070	2.50	95.32	8.75	27.67	1000000
Manganese (Mn)	209.80	30.52	31.40	306.01		0.560	5.48	0.63	14.79	178.28	
Nickel (Ni)	11.32	5.10	2.43	5.22		< 0.010	13832.29	1.25	1.25	1.25	
Lead (Pb)	64.52	37.96	140.14	1499.00	12000	3.910	114831.70	5.00	48.55	5.00	
Antimony (Sb)	< 0.11	< 0.11	< 0.11	0.16	500	< 0.110	147509.79	13.75	56.38	13.75	
Selenium (Se)	< 0.05	< 0.05	< 0.05	0.07		< 0.050	2945.01	6.25	6.25	6.25	
Thallium (Tl)	34.91	11.99	15.81	2.68		< 0.190	20.00	23.75	23.75	23.75	
Zinc (Zn)	245.79	1588.19	1914.58	6621.49	1000	6.880	10863.01	3.13	148.08	24.05	
Bismuth (Bi)							150.00	392691.60	8870.89	1766.67	
Calcium (Ca)							865.81	9.84	592.71	439444.70	
Magnesium (Mg)							308.52	168.39	6134.55	3580.27	
Strontium (Sr)							13.82	32.10	473288.55	325.33	
Tellurium (Te)							77399.91	5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since contribution is negligible

Table 3.5

CONDITION #1 SUMMARY OF WASTE METAL FEED RATES

(pounds per hour)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.0017	0.0000		0.0000	0.0028	0.0000	0.0000	0.0000		**0.0046**
Arsenic (As)	0.0013	0.0000		0.0235	1.3889	0.0001	0.0001	0.0001		**1.4141**
Barium (Ba)	0.0827	0.1555		0.0017	0.0000	0.0000	0.6571	0.0001		**0.8971**
Beryllium (Be)	0.0284	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000		**0.0285**
Cadmium (Cd)	0.0023	0.0000		0.0000	0.0002	0.0000	0.0000	0.0000		**0.0025**
Chromium (Cr)	0.0508	0.0012	48.7807	0.0000	0.0006	0.1792	0.0024	0.0000		**49.0150**
Copper (Cu)	0.2572	0.0007	24.3903	0.0030	0.0217	0.0000	0.0002	0.0000		**24.6733**
Mercury (Hg)	0.0004	0.0001		0.0004	0.0001	0.0014	0.0001	0.0004	1.7106	**1.7135**
Manganese (Mn)	0.1434	0.0402		0.0008	0.0001	0.0000	0.0002	0.0026		**0.1874**
Nickel (Ni)	0.0068	0.0003		0.0001	0.0027	0.0000	0.0000	0.0000		**0.0099**
Lead (Pb)	0.0262	0.0025	32.5205	0.0032	4.8293	0.0001	0.0007	0.0001		**37.3824**
Antimony (Sb)	0.0000	0.0000	1.3550	0.0006	0.5082	0.0002	0.0008	0.0002		**1.8651**
Selenium (Se)	0.0065	0.0000		0.0003	0.0012	0.0001	0.0001	0.0001		**0.0082**
Thallium (Tl)	0.0215	0.0004		0.0035	0.0003	0.0004	0.0004	0.0004		**0.0268**
Zinc (Zn)	0.1173	0.0622	1.7840	0.0083	0.8742	0.0000	0.0022	0.0004		**2.8486**
Bismuth (Bi)					0.0012	5.7903	0.1308	0.0260		**5.9484**
Calcium (Ca)					0.0069	0.0001	0.0087	6.4797		**6.4955**
Magnesium (Mg)					0.0029	0.0025	0.0905	0.0528		**0.1486**
Strontium (Sr)					0.0000	0.0005	6.9788	0.0048		**6.9840**
Tellurium (Te)					0.0063	0.0001	0.0007	0.0007		**0.0079**

Table 3.6

CONDITION #2 SUMMARY OF WASTE METAL FEED RATES

(pounds per hour)

Parameter	Soil	Paint	Paint & Soil	Debris	Capacitors	Liquid Feed	Telurium Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.0000	0.0000	0.0000	0.0000		0.0000	0.0001	0.0000	0.0000	0.0000		0.0003
Arsenic (As)	0.0034	0.0000	0.0000	0.0000		0.0094	0.0122	0.0001	0.0001	0.0001		0.0254
Barium (Ba)	0.0777	0.0999	0.0181	0.0956		0.0025	0.0000	0.0000	0.6236	0.0000		0.9175
Beryllium (Be)	0.0002	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000		0.0003
Cadmium (Cd)	0.0008	0.0003	0.0000	0.0000		0.0000	0.0003	0.0000	0.0000	0.0000		0.0015
Chromium (Cr)	0.2971	0.0041	0.0009	0.0103	19.0243	0.0019	0.0001	0.1701	0.0023	0.0000		19.5111
Copper (Cu)	0.0470	0.0128	0.0002	0.0003	9.5121	0.0021	0.0453	0.0000	0.0002	0.0000		9.6200
Mercury (Hg)	0.0004	0.0045	0.0005	0.0000		0.0005	0.0000	0.0013	0.0001	0.0004	1.8512	1.8589
Manganese (Mn)	0.0624	0.0170	0.0010	0.0121		0.0018	0.0000	0.0000	0.0002	0.0024		0.0970
Nickel (Ni)	0.0037	0.0015	0.0001	0.0002		0.0001	0.1232	0.0000	0.0000	0.0000		0.1288
Lead (Pb)	0.0202	0.0147	0.0046	0.0619	12.6828	0.0129	1.0230	0.0001	0.0007	0.0001		13.8210
Antimony (Sb)	0.0000	0.0000	0.0000	0.0000	0.5285	0.0007	1.3141	0.0002	0.0008	0.0002		1.8445
Selenium (Se)	0.0000	0.0000	0.0000	0.0000		0.0003	0.0262	0.0001	0.0001	0.0001		0.0269
Thallium (Tl)	0.0112	0.0033	0.0005	0.0001		0.0013	0.0002	0.0003	0.0003	0.0003		0.0176
Zinc (Zn)	0.0757	0.4001	0.0625	0.2321	1.0569	0.0227	0.0968	0.0000	0.0021	0.0003		1.9493
Bismuth (Bi)							0.0013	5.4948	0.1241	0.0239		5.6441
Calcium (Ca)							0.0077	0.0001	0.0083	5.9734		5.9895
Magnesium (Mg)							0.0027	0.0024	0.0858	0.0481		0.1391
Strontium (Sr)							0.0001	0.0004	6.6225	0.0044		6.6275
Tellurium (Te)							0.6895	0.0000	0.0007	0.0007		0.6909

Table 3.7

PROCESS DATA SUMMARY APTUS TEST PROGRAM

CONDITION #1: RUNS #1, #2, and #3

ITEM	UNIT	RUN #1 April 25, 1989 AVERAGE	RUN #1 April 25, 1989 STAN DEV	RUN #2 April 25, 1989 AVERAGE	RUN #2 April 25, 1989 STAN DEV	RUN #3 April 26, 1989 AVERAGE	RUN #3 April 26, 1989 STAN DEV	CONDITION #1 April 25-26, 1989 AVERAGE	CONDITION #1 April 25-26, 1989 STAN DEV
Feed	BTU/HR	52900.0	784.2	57425.0	2889.1	59175.0	1261.7	56500.0	901.0
Kiln	RPM	3.5	0.9	3.4	2.0	3.0	0.0	3.3	0.8
Kiln Temp.	°F	1701.8	81.3	1637.0	80.0	1752.8	58.8	1697.2	10.3
Kiln - High O2/Hr	%	11.4	1.1	13.2	2.5	11.4	2.7	12.0	0.7
Kiln - Low O2/Hr	%	5.0	0.3	2.9	0.5	2.9	1.7	3.6	0.6
Afterburner Temp.	°F	2247.5	47.6	2188.4	60.3	2151.8	61.9	2195.9	6.4
Afterburner O2	%	10.4	5.7	8.8	0.3	6.9	1.7	8.7	2.3
Spray Dryer Temp.	°F	463.5	3.0	466.0	4.5	458.3	6.5	462.6	4.0
Baghouse Drop	Inch H2O	3.5	0.1					3.5	0.0
Scrubber pH		3.7	0.5	3.2	0.0	3.5	0.0	3.5	0.2
SAT Temp.	°F	165.8	1.3	159.6	11.3	165.3	1.3	163.5	4.7
SAT Adsorber pH		4.1	0.3	2.9	0.2	3.4	0.4	3.5	0.1
IWS #1 Flow	GPM	5.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0
IWS #2 Flow	GPM	5.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0
IWS #2 pH		6.6	0.1	6.9	0.1	7.0	0.0	6.8	0.1
Neutralizer Tank pH		9.0	0.4	8.9	0.1	5.8	0.0	7.9	0.2
Stack Temp	°F	141.0	1.9	148.6	3.3	146.3	1.6	145.3	0.7
Stack Gas Flow	ACFM	28560.5	2985.2	32421.0	846.6	31396.3	140.8	30792.6	1209.3
Stack CO	ppm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3.8

PROCESS DATA SUMMARY APTUS TEST PROGRAM

CONDITION #2: RUNS #4, #5, and #6

		RUN #4 April 26, 1989		**RUN #5** April 27, 1989		**RUN #6** April 27, 1989		**CONDITION #2** April 26-27, 1989	
ITEM	**UNIT**	AVERAGE	STAN DEV	AVERAGE	STAN DEV	AVERAGE	STAN DEV	AVERAGE	STAN DEV
Feed	BTU/HR	54901.0	2135.8	51933.3	3225.8	53465.6	3440.7	53433.3	571.2
Kiln	RPM	5.8	1.3	4.0	1.0	5.0	0.0	4.9	0.6
Kiln Temp.	°F	1721.0	25.5	1690.2	63.1	1688.2	163.1	1699.8	58.0
Kiln - High O2/Hr	%	9.7	0.5	11.4	1.3	9.6	1.9	10.2	0.6
Kiln - Low O2/Hr	%	3.9	0.7	3.9	0.7	5.1	1.1	4.3	0.2
Afterburner Temp.	°F	2218.3	22.6	2187.3	29.3	2240.8	59.4	2215.5	16.0
Afterburner O2	%	10.0	6.1	6.7	1.4	6.8	1.4	7.8	2.2
Spray Dryer Temp.	°F	459.0	0.8	459.3	2.0	461.6	0.5	460.0	0.6
Baghouse Drop	Inch H2O	5.0	0.3	4.3	0.5	4.9	0.5	4.7	0.1
Scrubber pH		3.0	0.2	3.0	0.3	3.6	0.3	3.2	0.1
SAT Temp.	°F	165.8	0.8	168.5	1.4	169.0	2.0	167.8	0.5
SAT Adsorber pH		3.1	0.3	3.1	0.4	3.5	0.2	3.2	0.1
IWS #1 Flow	GPM	5.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0
IWS #2 Flow	GPM	5.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0
IWS #2 pH		5.8	0.3	5.9	0.1	5.7	0.0	5.8	0.1
Neutralizer Tank pH		5.4	0.8	5.1	1.8	6.4	0.3	5.6	0.6
Stack Temp	°F	145.5	0.9	147.7	2.3	147.2	2.5	146.8	0.7
Stack Gas Flow	ACFM	32546.3	612.7	31585.7	1345.1	30953.2	2870.2	31695.0	940.3
Stack CO	ppm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3.9

PROCESS DATA SUMMARY APTUS TEST PROGRAM

COMPARISON of CONDITION #1 and CONDITION #2

		CONDITION #1 April 25-26, 1989		CONDITION #2 April 26-27, 1989		PROGRAM April 25, 26, 27, 1989	
ITEM	**UNIT**	AVERAGE	STAN DEV	AVERAGE	STAN DEV	TOTAL AVERAGE	TOTAL STAN DEV
Feed	BTU/HR	56500.0	901.0	53433.3	571.2	54966.7	164.9
Kiln	RPM	3.3	0.8	4.9	0.6	4.1	0.1
Kiln Temp.	°F	1697.2	10.3	1699.8	58.0	1698.5	23.9
Kiln - High O2/Hr	%	12.0	0.7	10.2	0.6	11.1	0.1
Kiln - Low O2/Hr	%	3.6	0.6	4.3	0.2	3.9	0.2
Afterburner Temp.	°F	2195.9	6.4	2215.5	16.0	2205.7	4.8
Afterburner O2	%	8.7	2.3	7.8	2.2	8.3	0.0
Spray Dryer Temp.	°F	462.6	4.0	460.0	0.6	461.3	1.8
Baghouse Drop	Inch H2O	3.5	0.0	4.7	0.1	4.1	0.0
Scrubber pH		3.5	0.2	3.2	0.1	3.3	0.1
SAT Temp.	°F	163.5	4.7	167.8	0.5	165.6	2.1
SAT Adsorber pH		3.5	0.1	3.2	0.1	3.4	0.0
IWS #1 Flow	GPM	5.0	0.0	5.0	0.0	5.0	0.0
IWS #2 Flow	GPM	5.0	0.0	5.0	0.0	5.0	0.0
IWS #2 pH		6.8	0.1	5.8	0.1	6.3	0.0
Neutralizer Tank pH		7.9	0.2	5.6	0.6	6.7	0.2
Stack Temp	°F	145.3	0.7	146.8	0.7	146.0	0.0
Stack Gas Flow	ACFM	30792.6	1209.3	31695.0	940.3	31243.8	134.5
Stack CO	ppm	0.0	0.0	0.0	0.0	0.0	0.0

4.0 SUMMARY AND EVALUATION OF RESULTS

The results of the tests conducted at the Aptus Coffeyville facility are presented and discussed in this section. Tests were conducted at two different feed conditions. The two conditions are summarized in Table 3-1, page 3-5. As stated in Section 3.1, a variety of wastes were grouped to maximize the thermal input to the incineration system and the overall metals content of the waste feed to yield two different conditions with respect to chlorine content. The waste feed for the first condition had a chlorine feed content of approximately 10 percent; representative of a RCRA hazardous waste incinerator treating chlorinated spent solvent and organic wastes. The feed materials included contaminated soil, debris, capacitors, wastewater, PCB liquid, and a spent caustic slag. The waste feed for the second condition had a chlorine feed content of approximately 20 percent; representative of a RCRA and TSCA hazardous waste incinerator treating the chlorinated spent solvent and organic wastes as well as PCB solids and liquids. The feed materials were similar except that contaminated soil was blended with a latex paint prior to being placed in drums and a slag from selenium and tellurium processing was used instead of the spent caustic slag.

During each test run, particulate, metals and HCl flue gas sampling was conducted at the baghouse outlet and the stack. Also particulate and metals flue gas sampling was conducted at the afterburner outlet (spray dryer inlet). Samples of each of the waste feeds, kiln slag, baghouse ash, as well as samples from the brine recirculation system were also collected and analyzed for metals content.

4.1 Particulate Emissions

Particulate concentrations measured for the afterburner outlet, the baghouse outlet and the scrubber stack are presented in Table 4-1. Particulate concentrations measured at the stack were similar for the two test conditions and were all below 0.011 gr/dscf at 7 percent O_2. The average stack particulate concentration for the first condition was 0.0054 gr/dscf at 7 percent O_2. The average stack particulate concentration for the second condition was 0.0075 gr/dscf at 7 percent O_2. The average stack particulate concentration for all six test runs is 0.0064 gr/dscf at 7 percent O_2, which is below the TSCA limit of 0.08 gr/dscf.

Review of the data presented in Table 4-1 shows good precision between triplicate tests conducted for each test condition and for each test location. The scrubber stack concentration measured for Run 1 appears inconsistent with other data for this sampling location. The concentration measured was lower than the other runs by approximately a factor of 10. However, a thorough review of calculations and gravimetric analysis data for this test run shows no apparent error in the reported concentration.

Comparison of the averaged values presented in Table 4-1 shows similar particulate concentrations at the spray dryer inlet for each of the two test conditions. The average particulate concentrations corrected to 7 percent O_2 for Conditions 1 and 2 were 2.43 and 2.08 gr/dscf, respectively. Average particulate concentrations at 7 percent O_2 for the baghouse outlet are considerably higher for test Condition 2 compared to Condition 1 (0.0477 vs. 0.0087 gr/dscf). The higher baghouse outlet particulate concentration for Condition 2 may be due to a higher amount of bismuth present in the waste feed and is discussed further in Section 4.3.

Flue gas particulate mass rates determined for the three test locations are presented in Table 4-2. Review of the data in Table 3-2 again shows good consistency between the triplicate tests performed at the two test conditions and a substantially higher mass emission rate at the baghouse outlet for Condition 2 compared to Condition 1.

4.2 HCl Emissions

The results of HCl sampling and analysis are presented in Tables 4-3 and 4-4. Stack HCl mass emission rates averaged 0.15 and 4.79 lb/hr for test

Conditions 1 and 2 respectively. HCl removal efficiencies averaged 99.97 and 99.77 percent for the two test conditions. These tests demonstrate that the air pollution control system is achieving a level of performance greater than the TSCA standard of 99 percent removal. Flue gas concentrations and mass rates presented in these tables show good precision for triplicate tests conducted at each test location and for each test condition. The average HCl concentrations and mass rates at the baghouse outlet for test Conditions 1 and 2 were 5,590 and 21,200 parts per million by volume (ppmv), respectively. The higher HCl concentration for the test Condition 2 was expected because of a higher total mass rate of chlorine in the waste feed for Condition 2 compared to Condition 1. It is interesting to note that the chlorine mass rates for the baghouse outlet are greater than the feed mass rates for Condition 2. This is again due to the higher chlorine content of the feed and the accumulation of chloride in the brine solution. As will be discussed under the metals emissions results, the accumulation in the chloride in the brine appears to be beneficial in mercury removal.

4.3 Metals Emissions

Flue gas metals concentrations and mass rates determined for the spray dryer inlet, the baghouse outlet and the stack are presented in Table 4-5. Metals concentrations presented in Table 4-5 have been normalized to 7 percent O_2 to allow comparison of between run precision for the triplicate tests conducted at each test condition. Metals mass emission rates are also presented in Table 4-5.

In general, removal of metals across the spray dryer and baghouse system was substantial, as demonstrated by the concentrations achieved (refer to Table 4-5). The spray dryer inlet concentrations were sufficient to demonstrate substantial removal (greater than 90 percent) for all metals except beryllium. A removal effectiveness of greater than 99 percent was achieved for:

Antimony
Arsenic
Barium
Cadmium
Chromium
Copper
Lead
Manganese
Nickel
Selenium
Silver
Strontium
Thallium
Zinc

These metals were removed to a concentration of less than 100 ug/dscm in most instances.

There was only sufficient beryllium present in the spray dryer inlet to demonstrate effective removal in Runs 1-3 and 5. There was an average of 88 percent removal effectiveness for beryllium across Runs 1-3 and 77 percent removal for Run 5. The concentration measured at the baghouse outlet was near or below the detection limit. One of the concerns that has been expressed about beryllium is that combustion of beryllium containing wastes yields fine submicron particulates that are difficult to remove with conventional air pollution control technology. These data show that the spray dryer and baghouse system provide effective beryllium removal. The addition of the wet scrubber train further enhances beryllium emission control.

Bismuth and mercury were present in the spray dryer inlet at substantial concentrations in all runs. The degree of removal across the spray dryer and the baghouse system for these metals was not comparable to that achieved for the other metals. The removal of bismuth appears to be dependent upon the chlorine content of the flue gas. Bismuth removal was more effective in the lower chlorine condition (Condition 1). Bismuth was removed further in both conditions in the wet scrubber train. The overall percent removal achieved by the wet scrubber trains appears to be comparable under both conditions. These data point out the importance of the understanding the chemical form of the metals in emission control. It is likely that the bismuth is present in a different chemical form in the two differing conditions. For example, the chlorine flue gas concentrations and chloride concentrations in the brine recirculation system increases observed from Condition 1 to Condition 2 likely yielded different forms of bismuth (as bismuth trichloride, bismuth oxychloride, and bismuth trioxide). The different forms will be present as different size particulate matter or condense and agglomerate onto particulate matter of different sizes that are removed with differing efficiencies.

There appears to be virtually no removal of mercury across the spray dryer and baghouse system. The spray dryer and baghouse outlet actually showed an increase of mercury concentrations relative to the spray dryer inlet concentrations for Condition 1, Run 3 and Condition 2. (As will be discussed later in this section, the mercury does accumulate in the brine recirculation system.)

Mercury removal across the wet scrubber train appears to be more effective under Condition 2 than Condition 1. The average mercury concentration achieved under Condition 2 was an order of magnitude lower than Condition 1. This provides another example of the importance of the chemical form of the meal in control of metal emissions. In this instance, the chlorine concentration increased in the flue gas and the chloride concentration in the brine recirculation system increased from Condition 1 to Condition 2. This resulted in an increase in the mercury chloride concentrations (decreasing mercury metal and mercuric oxide) in the flue gas. Mercuric chloride is known to be very soluble in acidic water (pH < 5 standard units) and as such the mercury removal is observed to be greater in Condition 2.

Bismuth did exhibit the similar removal behavior in the wet scrubber train as that of mercury, however, not with the same effectiveness. Mercury was removed to concentrations two orders of magnitude lower than that of bismuth for Condition 2.

The wet scrubber train appeared to enhance the removal of nickel and zinc from the flue gas exiting the spray dryer and baghouse system. As stated above, one of the concerns expressed about the control of metals emissions (and control of particulate emissions in the range of 0.01 to 0.02 gr/dscf) is the difficulty in capturing fine submicron particulate matter. The data collected at the spray dryer and baghouse system outlet demonstrate that appreciable quantities of nickel and zinc were present and were subsequently reduced in the wet scrubber train.

Review of the concentration data presented in Table 4-5 generally shows excellent precision for the triplicates test runs conducted at each of the three test locations and for each metal. The only significant outliers in the data set include an extremely high manganese concentration for Run 5 at the baghouse outlet and a low barium concentration for Run 2 at the afterburner outlet. The high manganese level in baghouse outlet Run 5 is believed to have resulted from contamination of the peroxide impingers with potassium permanganate from the final mercury impinger in the sample train. The reason for the low value reported for barium in afterburner outlet Run 2 is unknown.

As noted in Section 4.1, average particulate concentrations at the baghouse outlet for test Conditions 1 and 2 were 0.0087 and 0.0477 gr/dscf or 19,940 and 109,320 ug/dscm respectively. Based on the above comparison of relative metals concentrations and the fact that mercury would be largely in the vapor phase at baghouse outlet temperatures (approximately 400°F), it appears that bismuth contributes significantly to the higher total particulate concentration observed for both test conditions. The average concentration of bismuth was 9700 ug/dscm for test Condition 1 and 75,900 ug/dscm for Condition 2. The bismuth would account for a maximum of 48 percent of the particulate concentration in Condicion 1 and a maximum of 70 percent of the particulate concentration in Condition 2.

4.4 Metal-to-Particulate Ratios

The metals-to-particulate ratio is defined as the mass of a specific metal per unit mass of particulate matter (mg of metal per g of particulate). The ratio is calculated by dividing the metal concentration (ug/dscm) by the particulate concentration (mg/dscm). In general, this ratio will be higher for smaller particles because small particles have a higher surface area per unit mass and metals that have been vaporized in the combustion zone will condense on a particle in proportion to the available surface area. If a control device is removing large particles and allowing smaller (usually sub-micron) particulate to escape, the metals-to-particulate ratio will generally increase across the control system.

Metal-to-particulate ratios for tests conducted at the three flue gas sampling locations are presented in Table 4-6. For most of the metals, observed differences in the metal-to-particulate ratios for the three test locations are relatively small and are not believed to be statistically significant. However, the data in Table 4-6 show a significant increase in the metal-to-particulate ratio across the spray dryer/baghouse system for bismuth and for mercury. In the case of mercury, this observation would be expected since mercury would largely be present in the vapor phase at a temperature of 400°F and is not removed in proportion to baghouse particulate removal. The increase in the metals-to-particulate ratio for bismuth suggests that the bismuth passed through the baghouse also, possibly as a sub-micron size particulate.

4.5 Waste Feed Materials

Two feed conditions were established as discussed earlier (Section 3.1). This section presents the run-by-run analytical results for the feed materials metal content. The calculation of metals mass flow rates is also discussed.

4.5.1 Metal Waste Feed Concentrations

The analytical results (in parts per million) are reported as averages and represent various sample schemes for each feed stream. The metals concentration in the soil and debris (Condition 1) and in the soil and debris plus paint (Condition 2) varied from run-to-run while the metals concentration for the capacitors, liquid blend, caustic or tellurium slag, and the surrogate metals mixtures remained constant. The soil and debris concentrations are based on an analysis of a grab sample from each drum charged during a run. Each sample was analyzed for antimony, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, manganese, nickel, lead, antimony, selenium, silver, thallium, and zinc. Each of these analyses was averaged per sample type for the run and is reported. The nontoxic metals: bismuth, calcium, magnesium, and strontium, and the toxic tellurium, were not analyzed in these feeds or the liquid blend since they were not expected to be present in significant quantities. Concentrations of these metals were measured in the caustic slag, tellurium slag, and surrogate metals mixture samples. The slags and metals spikes were based on one sample analysis each as they represent consistent feed streams, unlike the soil and debris and paint feed materials. The aqueous feed was not analyzed for metals as the content of the metals of interest is anticipated to be below detection limits. The composition of the capacitors was provided by the original manufacturers. The analyses were provided for years of production. Liquid mercury was added and as such reported to be 1,000,000 parts per million.

Tables 4-7, 4-8, and 4-9 summarize the metals concentration for Runs 1, 2, and 3 (Condition 1). For metals of interest present in the feed matrix, the highest concentrations of each is as follows:

- Arsenic and silver were present at 94,195, and 190 ppm, respectively, in the caustic slag. All other stream contributions of these metals are negligible;
- Barium was present in the soil and debris in the 100 to 1,000 ppm range but was present at 44,565 ppm in the strontium spike;
- Beryllium was typically below 1 ppm in all samples except for a soil sample for Run 2 which averaged 170 ppm;
- Cadmium was typically less than 10 ppm;
- Chromium was present in the capacitors at 1.8% and in the bismuth spike at 1.2 percent. For Runs 2 and 3, the soil exhibited chromium in the 300 ppm range;
- Mercury was reported as 100% for the liquid metal spike. The only other source was a 95 ppm level in the bismuth spike;

- Manganese was present in the 100 to 500 ppm range in the soil, debris, and magnesium spike;
- Nickel concentration was 183 ppm in the caustic slag and in the 1 to 13 ppm range for all other feed streams;
- Lead concentration was highest in the caustic slag at 32% followed by a level of 1.2% in the capacitors. The soil and debris spikes ranged from 1 to 60 ppm;
- Antimony concentration was analyzed as 3.4% in the caustic slag, at the 500 ppm level in the capacitors, and was not detected in the soil and debris while it ranged in the 10 to 60 ppm range in the spike metals;
- Selenium and thallium were of negligible concentration in most streams, but selenium was 80 ppm in the caustic slag while thallium was the 37 ppm level in the soil;
- Zinc constituted 5.9% of the caustic slag and 1,000 ppm in the capacitors while the debris ranged from 50 to 970 ppm. The soil ranged from 110 to 385 ppm; and
- The spike metals each contributed a significant level of the non-toxic metals with bismuth at 39% and strontium at 47 percent. The calcium content of the lime was 44% with magnesium present at the 3,580 ppm level.

A significant difference between Conditions 2 and 1 is found in the feed constituents and their respective metals content. Tables 4-10, 4-11, and 4-12 document the average metal content per run for each waste feed stream. For Runs 4, 5, and 6 (the Condition 2 tests), the feed streams included paint and paint filters. For these runs, the caustic slag was replaced with tellurium slag. Also, the blended liquid feed for Run 2 typically exhibited lower levels of metals. The metals spikes were the same for both Conditions 1 and 2 runs. The major metal concentration differences, therefore, were in the tellurium slag (versus the caustic slag) and the paint used in these runs. The key differences are as follows:

- Arsenic was nearly 100 times lower than in the tellurium slag at 1,371 ppm, while silver was 10 times lower at 16.4 ppm;
- Manganese was present in the 100 to 500 ppm range in the soil, debris, and magnesium spike;

- Nickel was about 100 times higher in the tellurium slag at 1.4 percent;
- Lead content of the tellurium slag was 3 times higher at 11.5 percent;
- Antimony was 5 times higher in the tellurium slag as opposed to the caustic slag at 14.8% level in the tellurium slag; and
- Zinc was 5 times lower in the tellurium slag at 1.1%, but ranged between 1,112 and 1,904 ppm in the paint feed.

It is significant to note that feed concentrations achieved were sufficient to permit analysis of gas and particulate metals concentrations throughout the air pollution system. These analyses permitted evaluation of the removal efficiencies of the various pollution control devices in the APCD train. Finally, the feed concentrations permitted evaluation of the metals discharging from the stack even though the cumulative reductions were substantial.

4.5.2 Metal Waste Mass Feed Rates

Combining the metal concentration in a given feed with the charge rate yielded the calculated mass rate of each metal for each feed stream. The individual stream values were summed for each run and averaged for the three triplicate runs that constitute a test condition. The results are reported in Tables 4-13 through 4-18. This section discusses the metals feed rates for the test runs that make up Condition 1 and Condition 2.

Runs 1, 2, and 3 had similar metals mass feed rates. Tables 4-13, 4-14, and 4-15 summarize the waste metal feed rate (in pounds per hour) for each stream. The total hourly metal feed rate is shown to be similar from run to run with Run 3 exhibiting a slightly higher overall feed rate for most metals. An examination of the individual metals rates indicates that the capacitor feed stream contributes the majority of six metals:

- Chromium had the highest metal feed rate at 48.1 to 50.8 pounds per hour with nearly 98% of it being derived from the capacitor feed;

- Lead, the second highest metal feed rate, at 36.7 to 38.8 pounds per hour. Of this total, 4.7 to 5 pounds per hour were derived from the caustic slag and most of the remainder from the capacitors;

- Copper is primarily derived from the capacitors, ranging from 24.4 to 25.3 pounds per hour;

- Antimony and zinc both come primarily from the capacitors, but both metals are also found in the caustic slag. The total feed rate for both was in the 2 to 4 pound per hour range.

Other toxic metals of interest that are not present to a significant level in the capacitors include arsenic, barium, and mercury. Arsenic was found at 1.42 pounds per hour with the primary source being the caustic slag. Mercury had a similar charge rate at 1.71 pounds per hour which was due solely to the liquid mercury spike feed rate. Barium was fed at 0.897 pounds per hour and had a minor contribution from the soil, about 17% from the debris consisting of paint filters, and the remainder from the strontium spike.

The nontoxic surrogate metals find their source from the spikes intentionally added to the wastes. It should be noted that most of those metals do exist in soil and possibly the debris streams, however, since the amount contributed by these systems should be small compared to the spike amounts, they were not analyzed for the spike metals. Thus, the minimum level fed is at least that of the spike streams added. These levels in pounds per hour are 5.8 for bismuth, 6.3 for calcium, 0.15 for magnesium, and 6.8 for strontium.

Runs 4, 5, and 6 had similar metals mass feed rates. Tables 4-16, 4-17, and 4-18 summarize the waste metal feed rates (in pounds per hour) for each stream. The metals concentrations for Run 4 have somewhat higher metal feed rates than Runs 5 or 6, however, all runs are similar and the results are reported in Table 3-16 which presents the average of each metal for each run in Condition 2. The significant points to note are:

- Chromium averaged 19.5 pounds per hour;
- Lead averaged 13.8 pounds per hour;
- Copper averaged 9.62 pounds per hour;
- Zinc averaged 1.94 pounds per hour;
- Mercury averaged 1.86 pounds per hour due to its spike; and
- Antimony averaged 1.84 pounds per hour with its main source from the capacitors.

The mass feed rate of other toxic metals averaged in the fractions of a pound range; barium being 0.92 pounds per hour and nickel at 0.13 pounds per hour. All others were below these levels. The surrogate metals ranged in the 5 to 6 pounds per hour charge rate except for magnesium at 0.14 pounds per hour. Tellurium averaged 0.69 pounds per hour, however, the feed rate per run was 1.22 for Run 4 and 0.5 for Runs 5 and 6. This variance in the feed rate was due to a 50% of the charge rate from 1 to 0.5 pounds per drum caused by a shortage of tellurium slag for "spiking." The use of tellurium instead of caustic slag for Condition 2 runs reduced the arsenic level by a factor of 60 to only 0.023 pounds per hour.

4.6 Kiln/Afterburner Slag Characterization

The concentrations and mass rates of metals in slag discharges from the kiln and afterburner were evaluated and these results are reported in this section. For each run, a composite sample of the slag was obtained from the deslagging quench and analyzed. For Run 1, the entire slag catch was blended and sampled to obtain a composite sample. For remaining runs, composite samples were obtained by collecting a grab sample of the slag as it discharged into the hopper on a 15-minute interval through the run. Each of these samples were then blended to obtain a sample for analysis. Both methods of sampling are appropriate to obtain a representative sample for analysis. The Aptus laboratory analyzed each individual ash sample for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, tellurium, thallium, zinc, bismuth, magnesium, manganese, strontium, and calcium. The results of these analyses and the calculated outlet rates are presented below.

4.6.1 Slag and Ash Metals Concentrations

The concentration of the metals in the slag and ash outlet stream were determined for each of the six run samples. These analyses were then averaged for each test condition (1 and 2) and the results are reported in Tables 4-19 and 4-20.

The slag/ash samples for test Condition 1 were analyzed for 20 metals. Seven of the metals were found to be below the detection limit and, therefore, the result is noted with a "<" sign. The number reported is equal to one half the detection limit. Of particular interest to this program is the concentration of metals in the slag since those that were not detected in the slag represent materials which, if present in the feed in significant quantities, are carried with the flue gas into the APCD and must be removed there. These metals were antimony, arsenic, beryllium, selenium, silver, tellurium, and thallium. Metals which had a significant detectable level in the slag represent metals that were emitted, at least in part, in the slag and thus presented a reduced metals load to the air pollution control system. The concentration of these metals in the slag ranged from a high of 17,740 ug/g for copper to only 18 ug/g for cadmium. The bismuth result of 54,494 ug/g is suspect unless a determination can be made that an unusually high level of bismuth was present in the soil or debris feed stream to the kiln. Other metals concentrations of significance are as follows:

- Chromium exhibited the second highest toxic metal concentration at 3,310 ug/g;

- Manganese and nickel had similar concentrations in the 1,100 ug/g range;
- Barium at 450, zinc at 351, and lead at 221 ug/g are all in at a similar concentration;
- Mercury was not detected for Run 3 but averaged 97 ug/g for Runs 1 and 2; and
- Spike metals calcium, magnesium, and strontium had significant levels of 17,697, 2,211, and 445 ug/g, respectively.

The metals levels for Condition 2 were typically higher for the detectable metals than those for Condition 1. The nondetectable metals were the same with the exception of silver moving from not detected to 21 ug/g (detectable) and mercury falling below its detection limit. Of the detectable metals, the following observations and differences for Condition 2 are made:

- Chromium and barium concentrations increased three-fold to 10,115 and 1,278 ug/g, respectively;
- Manganese, nickel, and zinc values doubled to 2,825, 1,887, and 681 ug/g, respectively; and
- Calcium, magnesium, and strontium, the surrogate metals, also increased to 25,337, 3,975, and 1,158 ug/g.

The concentration increase for the spike metals may be due in part to a 40% reduction in total slag emitted during Condition 2 as compared to Condition 1, while the spike metal feed rate was held constant. Reasons for increases in toxic metals contained in the slag are, at present, not understood.

4.6.2 Slag and Ash Mass Rates

The concentration of each metal was combined with the slag discharge rate from the kiln to yield the metal mass emission rates for each run and then averaged for each condition. The results of these are reported in Tables 4-21 and 4-22 for Conditions 1 and 2, respectively. In instances where the metal concentration was below the analytical detection limit, the outlet mass rate figure is annotated with a "<" sign which indicates that the emission rate is based on one half of the nondetection analytical limit.

For Condition 1, the metals discharge rates show which metals are present in the slag in significant quantities:

- Chromium's rate was calculated to be 16.66 pounds per hour;
- Manganese and nickel averaged 5.79 and 5.23 pounds per hour, respectively;
- The emission rates for barium and lead were 2.27 and 1.19 pounds per hour, respectively;
- Nontoxic metals which were present in the slag were calcium at 95 pounds per hour, copper at 86 pounds per hour, magnesium at 11 pounds per hour, and strontium at 2 pounds per hour; and
- Bismuth's 314 pounds per hour rate is suspect, again due to the analysis being suspect as noted earlier.

Condition 2 metals discharge rates reflect the higher metal concentrations reported in Section 4.6.1, above. The key metals of interest which have significant discharge rates in the slag are:

- Chromium, which nearly doubled at 35.24 pounds per hour;
- Manganese and nickel increased to 9.89 and 6.45 pounds per hour;
- Barium's rate doubled to 4.67, while lead was reduced somewhat to 0.88 pounds per hour;
- Nontoxic metals mass rates were: calcium at 94 pounds per hour, copper at 67 pounds per hour, magnesium at 15 pounds per hour, and strontium at 4 pounds per hour; and
- Bismuth's 620 pounds per hour rate is questionable due to the analysis being suspect.

4.7 Spray Dryer/Baghouse Ash and Solids Emissions

Metals which entered the spray dryer were fractionally removed by combination with the brine solution spray droplets or by condensation on particulate matter. Most of the solids created by the brine solution drying and fly ash were removed in the spray dryer and the baghouse. The solids dropout of the spray dryer and baghouse discharge are combined in a conveyor and transferred to tote bags. The tote bags were each thief sampled in four locations; bottom, mid, and top horizontal, plus a top diagonal sample. These samples were then individually analyzed. The individual metal analyses of each sample for a given tote bag were averaged. These average bag metal assays were then averaged for each run using a weighted average based on the weight of the tote bag sampled. Note that the ash samples from Run 3, the last run of Condition 1, and Run 4, the first run of Condition 2, were both conducted on April 26 and are not included in this calculation. These runs were not included because the ash system plugged and the ash from both runs was discharged together after both runs were complete. Thus, the metals averages used are for Runs 1 and 2, plus Runs 5 and 6. These runs were then averaged and the results are included in Tables 4-19 and 4-20 for Conditions 1 and 2, respectively.

4.7.1 Ash Metals Concentration

Condition 1 ash samples exhibited four nondetectable metals, beryllium, mercury, tellurium, and thallium. As with the slag, nondetectable results are reported in the tables as one half the detection limit and noted with a "<" sign. Of the metals which were present in nondetectable concentrations, the one of most interest for this stream is mercury. A nondetectable level indicates that little or no mercury was removed in the ash which came from this system.

Tables 4-19 and 4-20 list the metal concentrations in ug/g of solid analyzed. Of key interest are the concentrations of the toxic metals. High concentrations of certain metals are relevant to the overall partitioning between system components and significant to the disposal of the spray dryer/baghouse solids.

Condition 2 ash metal outlet concentrations were similar to those for Condition 1 with the following exceptions which are traceable to feed material differences between the test conditions:

- Arsenic was 5 times lower at 64 ug/g, reflective of the lower arsenic feed rate for Condition 2 relative to Condition 1; and
- Tellurium, at a 371 ug/g concentration in Condition 2, was nondetectable in Condition 1. This reflects the feed conditions in that tellurium was only fed during Condition 2 runs.

4.7.2 Ash Metals Outlet Rates

The mass discharge rates of metals in the ash from the spray dryer/baghouse system were calculated. The weight per tote bag and the concentrations reported above were used to determine the metals discharged per hour in this ash stream. The run averages were then combined to give the metal ash mass discharge rate reported for test Conditions 1 and 2 in Tables 4-21 and 4-22. As discussed in the above section, only Runs 1, 2, 5, and 6 results were used. Again, if a particular metal concentration was nondetectable, the discharge rate was calculated using one half of the detection limit.

Conditions 1 and 2 had similar outlet metals rates with the following exceptions:

- Arsenic for Condition 1 is calculated to be 0.42 pounds per hour, while Condition 2 had 40 times less arsenic discharge per hour at 0.097 pounds per hour. This is due to minimal amounts of arsenic being charged to Condition 2, while the caustic slag charged to Condition 1 contained significant amounts of arsenic;
- Tellurium for Condition 1 had virtually no discharge rate while Condition 2 had a rate of 0.56 pounds per hour, caused by the addition of tellurium slag to the feed for Condition 2; and
- Copper discharge rate for Condition 2 was 57% higher than Condition 1 which reflects the higher copper concentration reported in the feed.

The metals discharge rates for both test conditions represent only 2.5% of the total solids discharged from the system. The remainder of the solids discharged are from the caustic soda charged to Brine Solution I. It should be noted that metals not removed in the spray dryer/baghouse pass on to the subsequent flue gas control system. Thus, both fine particulate metals and those in a vapor phase will go to the quench and then the cross flow absorber. Both of these units, like the spray dryer, have Brine Solution I fed to them as a means of removal of both particulates, metals, and acid gas. The metals removal and/or accumulation in the brine solution circuits will be discussed in the next section.

4.8 Brine Solution Metals Contents

Seven samples of brine solution and makeup water were taken and analyzed for metals content. These metals include silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, manganese, nickel, lead, antimony, selenium, tellurium, thallium, zinc, bismuth, magnesium, strontium, and calcium.

Averaged results for the brine solution analyses are presented in Tables 4-23 and 4-24 for test Conditions 1 and 2, respectively. Other than the four surrogate metals, the metals present above the detection limit included silver, barium, chromium, copper, mercury, manganese, nickel, lead, and zinc. Of these, mercury was present at the highest concentration. The data show that for Condition 1 and Condition 2, six of the metals were below detectable levels. These metals included arsenic, antimony, beryllium, selenium, tellurium and thallium.

In Brine Solution I (Sample Number 11) and Brine Make-Up (Sample 10, a slipstream of Brine I), the mercury content averaged about 36.5 milligrams per liter (mg/L) (equivalent to 36.5 ppm). These solutions both feed the spray dryer, saturator, and absorber. The Brine rundown (Sample 12) stream averaged 26 mg/L. While Brine Solution II (Sample 13) average 1.4 mg/L and

Brine Solution III (Sample 14) averaged only 0.16 mg/L. And finally the mercury content for the make up to Brine Solution III (Stream 15) and the plant make up water (Stream 16) both had a mercury content below the detection limit[*] which is reported at 0.07 mg/L. The average mercury content for test Condition 2 exhibited higher concentration for each stream.

Copper had about the same average concentrations for Condition 1 and Condition 2. For Condition 1, the copper level for all streams was between 4.25 and 8.20 mg/L with the exception of the make up water which was below detection limits. An average of 60 mg/L was found in Brine Circuit #I, and its blowdown. Brine makeup, a sidestream taken from Brine Circuit #I, averaged 51 mg/L.

Copper exhibited one of the next highest concentrations in the brine circuits similar to the levels reported for Condition 1. Again the copper levels were relatively constant throughout all the main brine circuits averaging between 3.56 and 8.85 mg/L. The only exception was again the make up water, which showed a level below the reported detection limit of 0.02 mg/L.

Lead concentration encountered in test Condition 2 was double that exhibited in Condition 1. In Condition 2, lead had a high concentration of 9.69 mg/L, however, this high level was exhibited in Brine Circuit II and was more than three times higher than in the first brine circuits, Brine Solution I, Brine Make Up and Brine Rundown as well as Brine Solution II and its make up. The make up water had a level near the detection limit of 0.04 mg/L. Silver, chromium, manganese, nickel and zinc all had levels below 3.5 mg/L.

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[*] The values for all the metal analyses of the outfall stream that are below the detection limit are reported as one-half of that detection limit. Thus, in the case of mercury reported as 0.07 mg/L, the detection limit for the analysis performed was 0.14 mg/L.

Of the surrogate metals, bismuth tended to follow the trends that mercury exhibited for Condition 2. This did not hold true for Condition 1 where the bismuth level was non-detectable for all circuits except for the brine rundown which had an average level of 5.75 mg/L.

4.8.1 Concentration Changes in Brine Solution I

The scrubber brine circulation system is depicted in Figure 4-1. Brine Solution I, which feeds both the spray dryer and the quench and absorber vessels, is the most concentrated circuit. The accumulation of metals in this solution is presented in this section.

The concentration of key metals in Brine Solution I is 10 times higher than Brine Circuit II and 100 times higher than Brine Circuit III. Also, Brine Circuit I has the greatest volume of solution and is the primary solution which reacts with and contacts the particulate, metal and acid-laden flue gases. The brine solution accumulation discussed in this section is based on the analysis of two brine solutions samples per run. At the beginning of each run and at the end of each run, a sample of each brine solution circuit was taken. Thus, if a change in a metals level in the solution was observed between the start and finish of a run, it was reported as an accumulation through the run.

The accumulation or change in level of a metals concentration is reported in Tables 4-19 and 4-20 for Conditions 1 and 2, respectively. Of the metals analyzed, eight are below the detection limit in the solutions for both conditions, these include: antimony, arsenic, beryllium, cadmium, selenium, silver, tellurium, and thallium. Of the metals which were above the analytical limit, the change in concentration was negligible for barium, manganese, and nickel. Of the remaining metals analyzed, the following points should be noted:

- Chromium concentration increased in the brine solution from 0.878 to 4.685 mg/L for Conditions 1 and 2;

- Copper decreased 6.8 times from 8.063 to 1.190 mg/L;
- Lead decreased two-fold from 2.14 to 1.05 mg/L;
- Mercury, which had the highest concentration, increased 2.4 times from 36.48 to 88.25 mg/L;
- Zinc decreased 2.5 times from 1.77 to 0.71 mg/L; and
- Of the surrogate metals, bismuth showed the only significant increase, going up 390 times from 0.265 to 10,258 mg/L.

4.8.2 Rate of Accumulation in Brine Solution I

The increase in mass of a metal was calculated for each metal in Brine Solution I. This was accomplished by calculating the total weight of brine in the circuit (450,656 pounds) and applying concentration levels. The change, either accumulation or decrease (reflected by a "-" sign), of a metal in pounds per hour was calculated for each run. The run accumulations were averaged and the values reported in Tables 4-23 and 4-24 reflect those numbers. The metals which were not detected are indicated by a "<" sign. Those metals with negligible accumulation for both Conditions 1 and 2 were barium, manganese, nickel, and strontium. Chromium also exhibited negligible accumulation during Condition 1, while during Condition 2, lead and zinc had negligible accumulation.

4.9 Metals Partitioning

The metals charged in the waste feed stream are removed from the system in various outlet and emission streams. The analysis of metals and their emission rates were discussed in previous sections. These analyses are key to determination of where each metal is captured and discharged. For the purposes of this discussion, the incineration system will be simplified and the complex train of individual units will be grouped into three basic systems. This simplified system is shown in Figure 4-2 and consists of the following units:

- The incineration feed and combustion system including the kiln and the afterburner;
- The dry scrubbing system consisting of the spray dryer and baghouse; and
- The wet scrubbing system consisting of the quench, absorber, scrubber, and two wet ionizing wet scrubbers (IWS).

The feed streams that will be considered for this analysis will include:

- Each of the solid and liquid waste streams; contaminated soil, contaminated debris, PCB capacitors, and the blended liquid stream, all of which are treated as a single feed stream;
- The caustic soda added to the wet scrubbing system Brine Solution I; and
- The makeup water added to the wet scrubbing system Brine Solution III.

The combustion and fugitive air streams make up the majority of the vapor stream which passes through the entire incineration train. The vapor streams that flow between each of the major incineration units will be discussed as they carry the metals from unit to unit. These include:

- The outlet gases from the combustion system that feed the spray dryer; and
- The outlet gases from the dry scrubbing system that feed the wet scrubbing system.

Finally, the last stream to be considered with respect to metals partitioning will be the stack emissions.

The partitioning through the incineration system is presented for Conditions 1 and 2 in this section. Key metals will be discussed, including arsenic, chromium, lead, mercury, silver, zinc, and tellurium. All the metals analyzed are presented in Tables 4-25 and 4-26. Each figure presented is in pounds per hour of a given metal. Tables 4-27 and 4-28 provide the percentage distribution calculated for each measurement location or discharge point. The discussion follows the simplified process and stream presented above.

4.9.1 Condition 1

Arsenic

Arsenic is a key trace metal in the test program and was charged in significant quantity to Condition 1 only. Referring to Tables 4-25 and 4-26, arsenic partitioning through the system shows the following profile:

- Of the approximately 1.416 pounds per hour (lbs/hr) charged, the analysis accounts for 0.28 lbs/hr going out in the slag and 0.8467 lbs/hr leaving the afterburner in the flue gas stream. The partitioning indicated for arsenic across the incineration system is 25% to the slag and 75% to the dry scrubbing system. This calculation is, however, based on an assumption that the actual concentration in the slag is one-half of the detection limit. Using the full range of possible concentrations represented by the detection limit of the analytical methods, i.e., 0% to 100% of the detection limit, the capture of arsenic in the incinerator slag should range from 0% to 50% of the mass feed rate. The higher capture figure correlates more closely with the arsenic quantities found in the spray dryer and baghouse solid discharge, providing some small indication that the 50% split between the incinerator slag and the exiting flue gas may be the more likely situation.

- Of the arsenic entering the dry scrubbing system, 0.42 lbs/hr are removed in the ash and only 0.0013 lbs/hr enter the wet scrubbing system via the baghouse exit flue gas. The partitioning across the dry scrubber shows 99.8% leaving in the fly ash and 0.2% being passed to the wet scrubbing system.

- The wet scrubbing system shows no accumulation of arsenic in solution, however, the arsenic content of particulate matter obtained from the flue gas indicates that 89.5% removal efficiency of arsenic was achieved by the four scrubbers.

- The overall partitioning of arsenic suggests that 0% to 50% is removed in the slag, that 50% to 100% was removed in the ash stream. Based on the flue gas measurements, 0.13% was removed by the wet scrubbing system and only 0.02% was emitted from the stack.

Chromium

Chromium primarily came from the capacitors charged to the incineration system at a feed rate of 49 lbs/hr. The partitioning analysis shows that:

- 99.32%, or nearly all, of the chromium was removed in the slag;
- Only 0.677% was removed in the fly ash;
- While 0.0001% was emitted from the stack.

Mercury

As expected, mercury behaves quite differently from most of the other metals studied. Primary removal was not in the slag as with the other metals. The results are as follows:

- Only 28.65% of the mercury was removed in the slag. This number is suspect as it represents calculation of the mercury based on a concentration equal to one-half of the detection limit.

- 57.50% of the mercury was removed in the ash.

- There was an accumulation of mercury in the brine solution. This accumulation was 13.82 percent. Again the solution was fed back into the dry scrubber where a portion of the mercury was removed in the ash while the rest was reabsorbed back into the brine solution.

- The stack emissions accounted for 0.0192% of the mercury.

The evaluation of mercury partitioning through material balance is, as with arsenic, hampered by the extremely low concentrations in the large quantity of slag discharged from the incinerator. A mass balance analysis is further hampered by the complexity of the brine solution circuits and the fact that the mercury "catch" from both the spray dryer and the wet scrubbing systems is removed from the system in the spray dryer/baghouse ash. Nonetheless, the flue gas sampling results, coupled with accumulation of mercury in the brine circuits provide confirmation of two important, though not unexpected, results. The first of these is that the spray dryer/baghouse combination, with its rather elevated temperature, is not highly effective in removing mercury, most of which exits the incinerator as a vapor. The second conclusion, based on flue gas measurements at the stack, is that the wet scrubbing portion of the air pollution control train is quite effective in controlling mercury with only 0.02% of the mercury feed exiting via the stack. It is clear that any incinerator system burning wastes which contains substantial quantities of mercury must include wet (cold) scrubbers and effective small particle removal as part of the APCD train.

Silver

The partitioning of silver follows more typical heavy metal behavior with most of the silver being removed in the incinerator slag. The results are as follows:

- 91.19% of the silver was removed in the slag;
- 8.806% was removed in the ash stream;
- There was negligible accumulation of silver in the brine solution; and
- Overall removal efficiencies indicate that only 0.00004% was emitted in the stack gas.

Lead and Zinc

Both of these metals are primarily removed by the dry scrubber in the ash stream. The results are as follows:

- Only 19.43% of the lead and 15.98% of the zinc are removed in the slag;
- 80.47% of the lead and 83.71% of the zinc are removed in the ash;
- Accumulation of lead and zinc in brine circuits was virtually zero; and

- Stack emissions were 0.000045 and 0.0047% for lead and zinc, respectively.

4.9.2 Condition 2

For Condition 2, the metals partitioning is reported in Tables 4-25 and 4-26. The metals typically behaved as they did in Condition 1, with the following exceptions:

Mercury

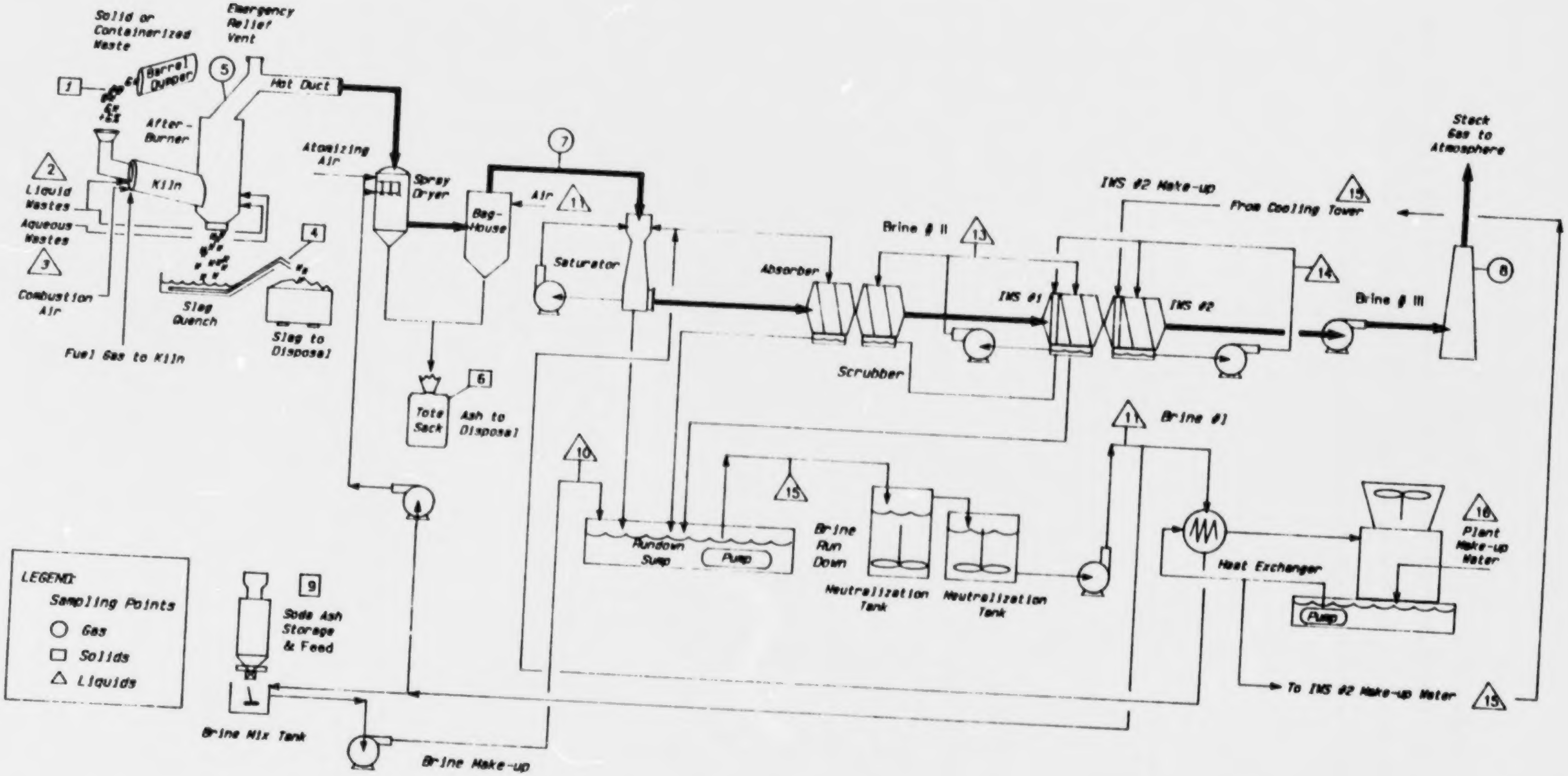
As in Condition 1 testing, the evaluation of mercury partitioning by mass balance was hampered by very low concentrations in the incinerator slag. The analysis of Condition 2 results indicated a somewhat different behavior in that mercury was below the detectable limit in the spray dryer/baghouse ash and exhibited a higher accumulation rate in the brine circuit. Although the high accumulation rate in the brine again points to the fact that major quantities are removed in the wet scrubbing portion of the air pollution control system, the overall different behavior between Conditions 1 and 2 is currently unexplained.

Lead and Zinc

The lead results between Conditions 1 and 2 are very similar, however, the zinc results show that twice as much zinc was removed in the slag for Condition 2. There was proportional decrease in the zinc removed by the ash stream and the accumulation rate showed a moderate increase in zinc. Finally, the stack emissions show a decrease in zinc.

Tellurium

Tellurium was only fed to the runs of Condition 2. Results show that nearly all of the tellurium fed remained in the slag stream. This result is expected as the source of the tellurium was itself a slag from another kiln operation. The stack emissions and intermediate vapor streams were not evaluated for tellurium, however, the brine and ash were. These results show virtually no tellurium present in these streams. Thus, tellurium acts much like chromium which also exhibited high removal in the slag.



Solid or Containerized Waste
1
Barrel Dumper
Emergency Relief Vent
5
Hot Duct
After-Burner
Kiln
2
Liquid Wastes
Aqueous Wastes
3
Combustion Air
Fuel Gas to Kiln
Slag Quench
4
Slag to Disposal
Atomizing Air
Spray Dryer
Bag-House
Air
11
7
Tote Sack
6
Ash to Disposal
Saturator
Absorber
Scrubber
Brine # II
13
IWS #1
IWS #2
IWS #2 Make-up
From Cooling Tower
15
14
Brine # III
8
Stack Gas to Atmosphere
10
15
Rundown Sump
Pump
Brine Run Down
Neutralization Tank
Neutralization Tank
11
Brine #1
Heat Exchanger
16
Plant Make-up Water
Pump
To IWS #2 Make-up Water
15
LEGEND:
Sampling Points
○ Gas
☐ Solids
△ Liquids
9
Soda Ash Storage & Feed
Brine Mix Tank
Brine Make-up

Figure 4-1
APTUS Incineration System
and Sampling Locations
Coffeyville, Kansas

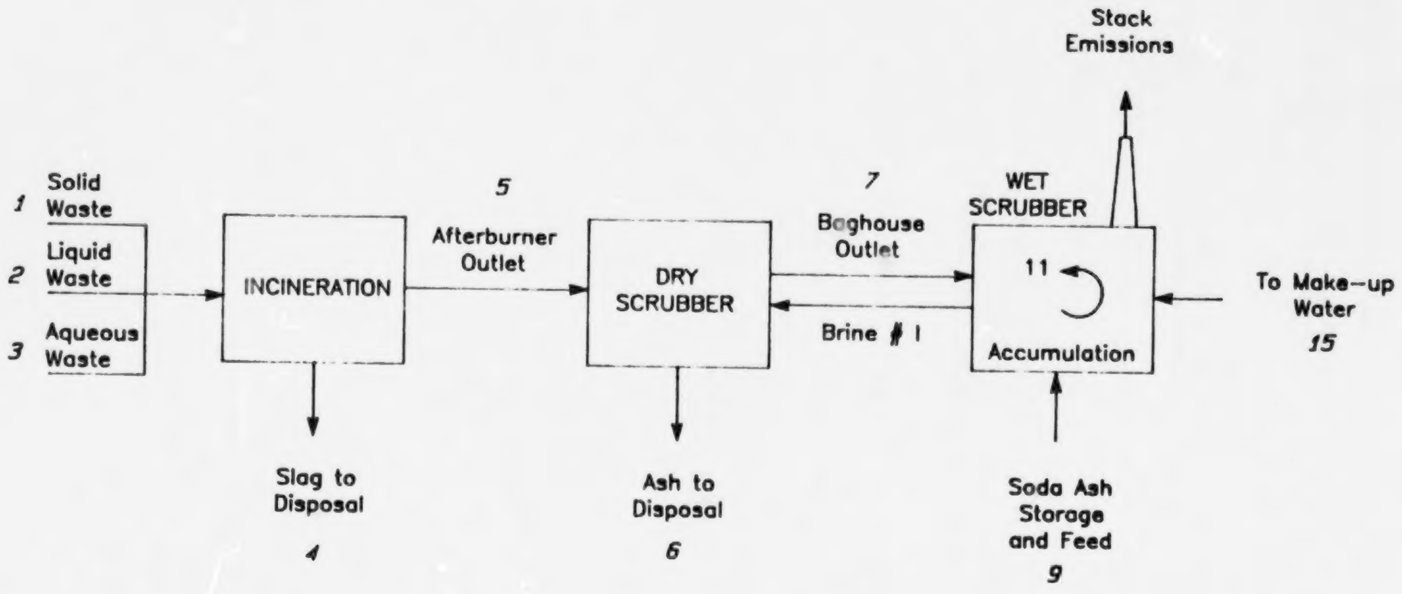

1 Solid Waste
2 Liquid Waste
3 Aqueous Waste
INCINERATION
5
Afterburner Outlet
DRY SCRUBBER
7
Baghouse Outlet
Brine # 1
WET SCRUBBER
11
Accumulation
Stack Emissions
To Make-up Water
15
Slag to Disposal
4
Ash to Disposal
6
Soda Ash Storage and Feed
9

Figure 4-2. Simplified APTUS Incineration System and Sampling Locations
Coffeyville, Kansas

TABLE 4-1. SUMMARY OF PARTICULATE CONCENTRATIONS

		Flue Gas Particulate Particulate Concentrations					
		Spray Dryer Inlet		Baghouse Outlet		Scrubber Stack	
Test Condition	Test Run Number	gr/dscf	gr/dscf @ 7% O_2	gr/dscf	gr/dscf @ 7% O_2	gr/dscf	gr/dscf @ 7% O_2
01	01	2.40	2.45	0.0061	0.0077	0.0005	0.0007
	02	2.17	2.24	0.0054	0.0063	0.0057	0.0074
	03	2.78	2.59	0.0087	0.0120	0.0056	0.0081
	Average	2.45	2.43	0.0067	0.0087	0.0037	0.0054
02	04	1.98	1.85	0.0401	0.0516	0.0026	0.0037
	05	2.59	2.42	0.0391	0.0538	0.0053	0.0081
	06	2.13	1.98	0.0347	0.0377	0.0077	0.0106
	Average	2.23	2.08	0.0376	0.0477	0.0052	0.0075

TABLE 4-2. SUMMARY OF PARTICULATE MASS EMISSION RATES

Test Condition	Test Run Number	Spray Dryer Inlet lb/hr	Spray Dryer Inlet g/hr	Baghouse Outlet lb/hr	Baghouse Outlet g/hr	Scrubber Stack lb/hr	Scrubber Stack g/hr
01	01	373	169,000	1.11	501	.085	38.6
	02	324	147,000	0.937	425	1.02	464
	03	343	156,000	1.50	682	1.07	486
	Average	347	157,000	1.18	536	0.726	329
02	04	243	110,000	6.40	2,900	0.498	226
	05	278	126,000	6.09	2,760	1.00	455
	06	284	129,000	5.03	2,280	1.40	633
	Average	268	122,000	5.84	2,650	0.965	438

TABLE 4-3. SUMMARY OF HCl FEED AND FLUE GAS EMISSION RATES

	Run 1	Run 2	Run 3	Avg.	Run 1	Run 2	Run 3	Avg.
Feed	656	760	681	699	1,849	1,851	1,865	1,855
Spray Dryer Baghouse Outlet	603	450	898	650	2,020	2,190	2,250	2,153
Stack	0.23	0.12	0.09	0.15	7.67	4.18	2.51	4.79
HCl Removal Efficiency (%)	99.96	99.98	99.99	99.98	99.59	99.77	99.87	99.74

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TABLE 4-4. SUMMARY OF HCl FLUE GAS CONCENTRATIONS

Test Condition	Test Run Number	Spray Dryer/ Baghouse Outlet mg/dscm	Spray Dryer/ Baghouse Outlet ppmv	Scrubber Stack mg/dscm	Scrubber Stack ppmv
01	01	7,660	5,040	2.84	1.87
	02	5,970	3,930	1.40	0.92
	03	11,800	7,780	1.02	0.67
	Average	8,490	5,590	1.75	1.15
02	04	28,900	19,000	92.0	60.5
	05	32,100	21,200	50.7	33.4
	06	35,500	23,300	31.9	21.0
	Average	32,200	21,200	58.2	38.3

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
		(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)
Antimony	1	10,071	287	53.7	1.53	41.4	2.28
	2	6,907	203	(23.4)	(0.685)	(24.4)	(1.46)
	3	16,589	412	124	3.06	(24.8)	(1.43)
	AVERAGE	11,189	301	67.0	1.76	30.2	1.72
	4	7,494	185	21.8	0.536	(24.0)	(1.42)
	5	5,650	127	51.5	1.16	(26.0)	(1.40)
	6	6,052	160	20.3	0.537	(24.5)	(1.42)
	AVERAGE	6,398	157	31.2	0.743	24.8	(1.42)
Arsenic	1	13,421	383	1.46	0.042	1.26	0.069
	2	15,673	460	1.57	0.046	2.27	0.136
	3	15,934	395	4.06	0.101	1.21	0.070
	AVERAGE	15,009	413	2.36	0.063	1.58	0.092
	4	49.5	1.22	0.262	0.006	0.104	0.006
	5	1,220	27.4	0.541	0.012	0.111	0.006
	6	2,306	61.1	0.365	0.010	0.125	0.007
	AVERAGE	1,763	29.9	0.389	0.009	0.113	0.006
Barium	1	890	25.4	4.83	0.138	4.65	0.257
	2	80.9	2.38	3.83	0.112	4.04	0.242
	3	1,987	49.3	5.29	0.131	3.52	0.203
	AVERAGE	1,439	25.7	4.65	0.127	4.07	0.234
	4	1,547	38.1	4.36	0.107	2.96	0.175
	5	1,780	40.0	6.89	0.155	1.06	0.057
	6	3,308	87.7	6.60	0.174	2.51	0.145
	AVERAGE	2,212	55.3	5.95	0.145	2.18	0.126

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM (CONTINUED)

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
		(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)
Beryllium	1	2.79	0.080	0.430	0.012	(0.148)	(0.009)
	2	(2.52)	(0.075)	(0.234)	(0.007)	(0.144)	(0.010)
	3	2.65	0.066	(0.278)	(0.007)	(0.147)	(0.009)
	AVERAGE	2.65	(0.074)	0.314	0.009	(0.146)	(0.009)
	4	(0.690)	(0.017)	(0.257)	(0.006)	(0.142)	(0.009)
	5	1.19	0.027	(0.275)	(0.006)	(0.154)	(0.009)
	6	(1.40)	(0.037)	(0.217)	(0.006)	(0.137)	(0.009)
	AVERAGE	(1.09)	(0.027)	(0.250)	(0.006)	(0.144)	(0.009)
Bismuth	1	82,409	2,352	6,447	184	(103)	(5.68)
	2	99,226	2,912	6,068	178	(100)	(6.02)
	3	103,688	2,573	16,588	411	201	11.6
	AVERAGE	95,108	2,613	9,701	258	135	7.77
	4	109,822	2,707	80,099	1,971	2,859	169
	5	96,827	2,175	75,120	1,686	2,275	123
	6	108,069	2,864	72,565	1,919	2,811	162
	AVERAGE	104,906	2,582	75,928	1,859	2,648	151
Cadmium	1	416	11.9	3.65	0.104	4.65	0.257
	2	259	7.59	2.78	0.081	2.78	0.167
	3	395	9.82	3.65	0.090	1.51	0.087
	AVERAGE	357	9.76	3.36	0.092	2.98	0.170
	4	152	3.76	7.63	0.188	1.82	0.108
	5	131	2.94	3.22	0.072	1.90	0.103
	6	98.0	2.60	4.57	0.121	1.51	0.087
	AVERAGE	127	3.10	5.14	0.127	1.74	0.099

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM (CONTINUED)

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET (ug/dscm)^a	AFTERBURNER OUTLET (grams/hr)	BAGHOUSE OUTLET (ug/dscm)^a	BAGHOUSE OUTLET (grams/hr)	SCRUBBER STACK (ug/dscm)^a	SCRUBBER STACK (grams/hr)
Chromium	1	479	13.7	12.9	0.368	7.24	0.399
	2	710	20.8	7.66	0.224	6.05	0.364
	3	5,312	132	15.9	0.393	7.05	0.406
	AVERAGE	2,167	55.5	12.1	0.329	6.78	0.390
	4	641	15.8	13.1	0.322	4.93	0.291
	5	393	8.82	19.3	0.433	5.29	0.286
	6	1,729	45.8	12.7	0.336	2.01	0.116
	AVERAGE	921	23.5	15.0	0.364	4.08	0.231
Copper	1	139,681	3,986	25.2	0.721	12.9	0.713
	2	88,787	2,606	23.9	0.701	6.05	0.364
	3	92,909	2,306	24.7	0.612	11.1	0.638
	AVERAGE	107,126	2,966	24.6	0.678	10.0	0.572
	4	105,986	2,612	20.2	0.496	19.7	1.165
	5	223,023	5,009	41.8	0.939	7.41	0.400
	6	158,509	4,201	32.5	0.859	12.0	0.696
	AVERAGE	162,506	3,941	31.5	0.765	13.1	0.754
Lead	1	83,802	2,392	5.64	0.161	2.84	0.157
	2	79,639	2,337	5.03	0.147	1.67	0.100
	3	99,531	2,470	5.59	0.138	8.81	0.508
	AVERAGE	87,657	2,400	5.42	0.149	4.44	0.255
	4	65,890	1,624	27.0	0.664	48.1	2.84
	5	95,149	2,137	7.40	0.166	11.4	0.615
	6	67,720	1,795	3.04	0.081	23.8	1.38
	AVERAGE	76,253	1,852	12.5	0.303	27.8	1.61

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM (CONTINUED)

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
		(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)
Magnesium	1	(1117)	(31.9)	(106)	(3.04)	(103)	(5.68)
	2	(1045)	(30.6)	(95.8)	(2.81)	(100)	(6.02)
	3	1,327	32.9	(117)	(2.89)	(101)	(5.80)
	AVERAGE	1,163	(31.8)	(106)	(2.91)	(101)	(5.83)
	4	1,034	25.5	(108)	(2.66)	(97.4)	(5.76)
	5	1,338	30.1	193	4.33	(105)	(5.70)
	6	1,297	34.4	(101)	(2.67)	(99.5)	(5.75)
	AVERAGE	1,223	30.0	134	3.22	(101)	(5.74)
Manganese	1	939	26.8	11.8	0.337	0.517	0.029
	2	1,426	41.8	5.75	0.168	0.505	0.030
	3	1,850	45.9	5.88	0.146	1.01	0.058
	AVERAGE	1,405	38.2	7.82	0.217	0.676	0.039
	4	1,160	28.6	4.90	0.121	0.986	0.058
	5	1,631	36.6	154497	3467	52.9	2.86
	6	2,298	60.9	9.13	0.242	1.51	0.087
	AVERAGE	1,696	42.0	7.02	0.181	18.5	1.00
Mercury	1	21,426	611	9,719	277	119	6.58
	2	25,139	738	21,171	620	382	23.0
	3	24,299	603	39,478	978	123	7.11
	AVERAGE	23,622	651	23,456	625	208	12.2
	4	20,595	508	44,270	1,090	17.0	1.00
	5	27,542	619	59,952	1,345	14.2	0.766
	6	24,089	638	30,163	798	14.6	0.844
	AVERAGE	24,075	588	44,795	1,078	15.3	0.872

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM (CONTINUED)

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
		(ug/dscm)^a	(grams/hr)	(ug/dscm)^a	(grams/hr)	(ug/dscm)^a	(grams/hr)
Nickel	1	698	19.9	10.7	0.307	4.14	0.228
	2	366	10.7	12.0	0.351	(2.44)	(0.147)
	3	544	13.5	6.47	0.160	4.03	0.232
	AVERAGE	536	14.7	9.73	0.272	3.54	0.202
	4	627	15.4	18.5	0.456	4.93	0.291
	5	1,219	27.4	26.4	0.592	8.47	0.457
	6	865	22.9	18.3	0.483	12.5	0.725
	AVERAGE	903	21.9	21.1	0.510	8.65	0.491
Selenium	1	18.2	0.518	6.98	0.199	0.00	0.00
	2	18.3	0.536	0.575	0.017	0.00	0.00
	3	17.3	0.428	0.588	0.015	0.00	0.00
	AVERAGE	17.9	0.494	2.72	0.077	0.00	0.00
	4	256	6.31	1.36	0.034	0.296	0.017
	5	194	4.35	1.61	0.036	0.360	0.019
	6	271	7.19	2.13	0.056	0.402	0.023
	AVERAGE	240	5.95	1.70	0.042	0.352	0.020
Silver	1	55.9	1.59	(4.26)	(0.122)	(4.12)	(0.227)
	2	(25.2)	(0.740)	(3.74)	(0.110)	(4.01)	(0.241)
	3	53.1	1.32	(4.59)	(0.115)	(3.94)	(0.228)
	AVERAGE	44.7	1.22	(4.20)	(0.116)	(4.02)	(0.232)
	4	77.5	1.91	(4.25)	(0.106)	(3.81)	(0.226)
	5	59.5	1.34	13.5	0.303	(4.12)	(0.224)
	6	72.0	1.91	(4.02)	(0.106)	(3.95)	(0.228)
	AVERAGE	69.7	1.72	7.26	0.171	(3.96)	(0.226)

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM (CONTINUED)

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
		(ug/dscm)^a	(grams/hr)	(ug/dscm)^a	(grams/hr)	(ug/dscm)^a	(grams/hr)
Strontium	1	7,820	223	1.50	0.043	0.310	0.017
	2	5,482	161	1.39	0.041	0.404	0.024
	3	12,208	303	1.76	0.044	0.352	0.020
	AVERAGE	8,503	229	1.55	0.042	0.355	0.021
	4	12,918	318	1.09	0.027	(9.74)	(0.576)
	5	10,852	244	1.42	0.032	(10.5)	(0.569)
	6	9,795	260	1.62	0.043	(9.95)	(0.576)
	AVERAGE	11,188	274	1.38	0.034	(10.1)	(0.574)
Thallium	1	279	7.97	26.9	0.767	24.8	1.37
	2	261	7.66	23.9	0.701	9.08	0.545
	3	265	6.59	29.4	0.729	9.06	0.522
	AVERAGE	269	7.41	26.7	0.732	14.3	0.812
	4	258	6.37	27.2	0.671	11.3	0.67
	5	297	6.68	32.2	0.722	43.9	2.37
	6	288	7.64	25.4	0.671	85.8	4.96
	AVERAGE	281	6.90	28.3	0.688	47.0	2.67

TABLE 4-5. SUMMARY OF CONCENTRATIONS AND MASS RATES FOR THE APTUS TEST PROGRAM (CONTINUED)

PARAMETER	TEST RUN NUMBER	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
		(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)	(ug/dscm)[a]	(grams/hr)
Zinc	1	136,868	3,906	146	4.15	37.7	2.08
	2	31,327	919	115	3.37	55.5	3.33
	3	371,601	9,222	125	3.10	40.8	2.35
	AVERAGE	179,932	4,683	129	3.54	44.7	2.59
	4	41,380	1,020	228	5.61	0.246	0.015
	5	112,146	2,519	287	6.44	0.265	0.014
	6	79,241	2,100	504	13.3	0.502	0.029
	AVERAGE	77,589	1,880	340	8.46	0.338	0.019

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[a] Concentration results are presented as ug/dscm adjusted to 7 percent oxygen. Afterburner outlet results are adjusted using the plant's oxygen results due to apparent interferences in the Orsat analyses (EPA Method 3).

[b] Not detected compounds are indicated by brackets.

[c] If the target compound in the reagent blank is greater than the sample, the sample value is set to zero.

TABLE 4-6. SUMMARY OF AVERAGE FLUE GAS METALS-TO-PARTICULATE RATIOS FOR THE APTUS TEST PROGRAM

PARAMETER	AVERAGE METALS-TO-PARTICULATE RATIO (mg metal/gram particulate)					
	AFTERBURNER OUTLET		BAGHOUSE OUTLET		SCRUBBER STACK	
	RUNS 1-3	RUNS 4-6	RUNS 1-3	RUNS 4-6	RUNS 2-3	RUNS 4-6
Antimony	1.91	1.31	2.52	0.279	0.00	0.00
Arsenic	2.64	0.234	0.113	0.004	0.099	0.008
Barium	0.161	0.448	0.244	0.056	0.214	0.171
Beryllium	0.00	0.00	0.008	0.00	0.00	0.00
Bismith	16.7	21.3	463	710	5.42	193
Cadmium	0.062	0.026	0.177	0.048	0.122	0.127
Chromium	0.356	0.190	0.613	0.138	0.368	0.318
Copper	18.7	32.0	1.33	0.296	0.476	1.08
Lead	15.3	15.2	0.290	0.108	0.286	2.43
Magnesium	0.070	0.245	0.00	0.523	0.00	0.00
Manganese	0.246	0.341	0.427	0.074[a]	0.042	1.01
Mercury	4.17	4.82	1149	404	14.6	1.13
Nickel	0.093	0.178	0.557	0.194	0.108	0.520
Selenium	0.003	0.049	0.153	0.016	0.00	0.024
Silver	0.006	0.014	0.00	0.037	0.00	0.00
Strontium	1.45	2.28	0.082	0.013	0.511	0.00
Thallium	0.047	0.057	1.42	0.262	2.73	2.42
Zinc	29.5	15.2	6.92	3.37	0.021	0.021

[a] The manganese result for the Baghouse outlet-Run 5 is considered suspect and is not included in the average.

Table 4.7

RUN # 1 METAL FEED CONCENTRATIONS

(parts per million by weight)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.005	0.160		< 0.005	190.32	1.82	< 0.62	2.89	
Arsenic (As)	< 0.060	< 0.060		9.330	94195.16	< 6.88	< 6.88	< 6.88	
Barium (Ba)	92.464	815.800		0.680	< 2.500	2.77	44565.82	3.71	
Beryllium (Be)	1.130	< 0.010		< 0.005	< 0.500	< 0.63	< 0.63	< 0.63	
Cadmium (Cd)	2.868	0.210		< 0.005	12.10	< 0.63	< 0.63	< 0.63	
Chromium (Cr)	11.968	16.480	18000 a	< 0.005	42.74	12156.16	161.54	2.08	
Copper (Cu)	780.342	8.790	9000 b	1.190	1471.77	< 1.88	15.34	< 1.88	
Mercury (Hg)	< 0.070	1.410		0.070	< 5.00	95.32	8.75	27.67	1000000
Manganese (Mn)	416.746	447.890		0.300	5.65	< 0.63	14.79	178.28	
Nickel (Ni)	12.478	4.450		< 0.010	183.07	< 1.25	< 1.25	< 1.25	
Lead (Pb)	36.970	30.200	12000	1.250	327512.90	< 5.00	48.55	< 5.00	
Antimony (Sb)	< 0.110	< 0.110	500	< 0.110	34468.55	< 13.75	56.38	13.75	
Selenium (Se)	< 0.050	< 0.050		< 0.050	79.84	< 6.25	< 6.25	< 6.25	
Thallium (Tl)	36.856	4.680		1.400	< 20.00	< 23.75	< 23.75	< 23.75	
Zinc (Zn)	334.344	970.880	1000.00	3.270	59285.48	< 3.13	148.08	24.05	
Bismuth (Bi)					< 125.00	392691.60	8870.89	1766.67	
Calcium (Ca)					704.84	9.84	592.71	439444.70	
Magnesium (Mg)					292.08	168.39	6134.55	3580.27	
Strontium (Sr)					2.50	32.10	473288.55	325.33	
Tellurium (Te)					642.97	< 5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since metal contribution is negligible.

Table 4.8

RUN # 2 METAL FEED CONCENTRATIONS

(parts per million by weight)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Slag	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.01	< 0.01		< 0.005	190.32	1.82	< 0.62	2.89	
Arsenic (As)	< 0.06	< 0.06		9.330	94195.16	< 6.88	< 6.88	< 6.88	
Barium (Ba)	122.75	1099.36		0.680	< 2.500	2.77	44565.82	3.71	
Beryllium (Be)	169.91	< 0.01		< 0.005	< 0.500	< 0.63	< 0.63	< 0.63	
Cadmium (Cd)	2.41	< 0.01		< 0.005	12.10	< 0.63	< 0.63	< 0.63	
Chromium (Cr)	24.19	3.08	18000 a	< 0.005	42.74	12156.16	161.54	2.08	
Copper (Cu)	384.28	2.09	9000 b	1.190	1471.77	< 1.88	15.34	< 1.88	
Mercury (Hg)	8.26	< 0.07		0.070	< 5.00	95.32	8.75	27.67	1000000
Manganese (Mn)	367.28	119.77		0.300	5.65	< 0.63	14.79	178.28	
Nickel (Ni)	13.45	1.44		< 0.010	183.07	< 1.25	< 1.25	< 1.25	
Lead (Pb)	58.98	7.63	12000	1.250	327512.90	< 5.00	48.55	< 5.00	
Antimony (Sb)	< 0.11	< 0.11	500	< 0.110	34468.55	< 13.75	56.38	13.75	
Selenium (Se)	< 0.05	0.07		< 0.050	79.84	< 6.25	< 6.25	< 6.25	
Thallium (Tl)	27.74	0.25		1.400	< 20.00	< 23.75	< 23.75	< 23.75	
Zinc (Zn)	385.76	52.49	1000.00	3.270	59285.48	< 3.13	148.08	24.05	
Bismuth (Bi)					< 125.00	392691.60	8870.89	1766.67	
Calcium (Ca)					704.84	9.84	592.71	439444.70	
Magnesium (Mg)					292.08	168.39	6134.55	3580.27	
Strontium (Sr)					2.50	32.10	473288.55	325.33	
Tellurium (Te)					642.97	< 5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since metal contribution is negligible.

Table 4.9

RUN # 3 METAL FEED CONCENTRATIONS

(parts per million by weight)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.01	0.14		< 0.005	190.32	1.82	< 0.62	2.89	
Arsenic (As)	6.99	< 0.06		9.330	94195.16	< 6.88	< 6.88	< 6.88	
Barium (Ba)	294.70	722.33		0.680	< 2.500	2.77	44565.82	3.71	
Beryllium (Be)	1.33	< 0.01		< 0.005	< 0.500	< 0.63	< 0.63	< 0.63	
Cadmium (Cd)	2.81	< 0.01		< 0.005	12.10	< 0.63	< 0.63	< 0.63	
Chromium (Cr)	234.70	4.70	18000 a	< 0.005	42.74	12156.16	161.54	2.08	
Copper (Cu)	94.05	2.61	9000 b	1.190	1471.77	< 1.88	15.34	< 1.88	
Mercury (Hg)	0.95	0.44		0.070	< 5.00	95.32	8.75	27.67	1000000
Manganese (Mn)	103.02	193.81		0.300	5.65	< 0.63	14.79	178.28	
Nickel (Ni)	13.70	0.68		< 0.010	183.07	< 1.25	< 1.25	< 1.25	
Lead (Pb)	58.06	9.76	12000	1.250	327512.90	< 5.00	48.55	< 5.00	
Antimony (Sb)	< 0.11	< 0.11	500	< 0.110	34468.55	< 13.75	56.38	13.75	
Selenium (Se)	< 0.05	< 0.05		< 0.050	79.84	< 6.25	< 6.25	< 6.25	
Thallium (Tl)	61.02	2.94		1.400	< 20.00	< 23.75	< 23.75	< 23.75	
Zinc (Zn)	110.08	247.46	1000.00	3.270	59285.48	< 3.13	148.08	24.05	
Bismuth (Bi)					< 125.00	392691.60	8870.89	1766.67	
Calcium (Ca)					704.84	9.84	592.71	439444.70	
Magnesium (Mg)					292.08	168.39	6134.55	3580.27	
Strontium (Sr)					2.50	32.10	473288.55	325.33	
Tellurium (Te)					642.97	< 5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since metal contribution is negligible.

Table 4.10

RUN # 4 METAL FEED CONCENTRATIONS

(parts per million by weight)

Parameter	Soil	Paint	Paint & Soil	Debris	Capacitors	Liquid Feed	Telurium Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.01	0.05	< 0.01	0.19		< 0.005	16.44	1.82	< 0.62	2.89	
Arsenic (As)	< 0.06	< 0.06	< 0.05	< 0.06		2.860	1370.65	< 6.88	< 6.88	< 6.88	
Barium (Ba)	155.59	495.87	555.70	713.52		0.770	2.50	2.77	44565.82	3.71	
Beryllium (Be)	1.07	< 0.01	< 0.01	0.01		< 0.005	0.50	< 0.63	< 0.63	< 0.63	
Cadmium (Cd)	3.43	0.78	0.70	0.24		< 0.005	33.07	< 0.63	< 0.63	< 0.63	
Chromium (Cr)	355.37	4.87	28.37	8.41	18000 a	0.590	7.63	12156.16	161.54	2.08	
Copper (Cu)	251.55	4.78	6.42	2.90	9000 b	0.630	5085.13	< 1.88	15.34	< 1.88	
Mercury (Hg)	< 0.07	16.35	15.52	0.60		< 0.070	2.50	95.32	8.75	27.67	1000000
Manganese (Mn)	332.22	17.62	31.40	161.59		0.560	5.48	< 0.63	14.79	178.28	
Nickel (Ni)	14.95	6.08	2.43	0.43		< 0.010	13832.29	< 1.25	< 1.25	< 1.25	
Lead (Pb)	87.95	22.56	140.14	11.58	12000	3.910	114831.70	< 5.00	48.55	< 5.00	
Antimony (Sb)	< 0.11	< 0.11	< 0.11	< 0.11	500	< 0.110	147509.79	< 13.75	56.38	13.75	
Selenium (Se)	< 0.05	< 0.05	< 0.05	< 0.05		< 0.050	2945.01	< 6.25	< 6.25	< 6.25	
Thallium (Tl)	51.14	8.50	15.81	4.65		< 0.190	20.00	< 23.75	< 23.75	< 23.75	
Zinc (Zn)	319.16	1112.54	1914.58	390.46	1000	6.880	10863.01	< 3.13	148.08	24.05	
Bismuth (Bi)							150.00	392691.60	8870.89	1766.67	
Calcium (Ca)							865.81	9.84	592.71	439444.70	
Magnesium (Mg)							308.52	168.39	6134.55	3580.27	
Strontium (Sr)							13.82	32.10	473288.55	325.33	
Tellurium (Te)							77399.91	< 5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since metal contribution is negligible.

Table 4.11

RUN #5 METAL FEED CONCENTRATIONS

(parts per million by weight)

Parameter	Soil	Paint	Debris	Capacitors	Liquid Feed	Telurium Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.01	0.12	0.14		< 0.005	16.44	1.82	< 0.62	2.89	
Arsenic (As)	14.72	< 0.06	< 0.06		2.860	1370.65	< 6.88	< 6.88	< 6.88	
Barium (Ba)	297.07	143.88	722.33		0.770	2.50	2.77	44565.82	3.71	
Beryllium (Be)	0.75	< 0.01	< 0.01		< 0.005	0.50	< 0.63	< 0.63	< 0.63	
Cadmium (Cd)	2.87	0.90	< 0.01		< 0.005	33.07	< 0.63	< 0.63	< 0.63	
Chromium (Cr)	1407.30	18.71	4.70	18000 a	0.590	7.63	12156.16	161.54	2.08	
Copper (Cu)	157.90	6.85	2.61	9000 b	0.630	5085.13	< 1.88	15.34	< 1.88	
Mercury (Hg)	0.47	11.42	0.44		< 0.070	2.50	95.32	8.75	27.67	1000000
Manganese (Mn)	154.01	21.81	193.81		0.560	5.48	< 0.63	14.79	178.28	
Nickel (Ni)	13.62	5.39	0.68		< 0.010	13832.29	< 1.25	< 1.25	< 1.25	
Lead (Pb)	66.18	41.41	9.76	12000	3.910	114831.70	< 5.00	48.55	< 5.00	
Antimony (Sb)	< 0.11	< 0.11	< 0.11	500	< 0.110	147509.79	< 13.75	56.38	13.75	
Selenium (Se)	< 0.05	< 0.05	< 0.05		< 0.050	2945.01	< 6.25	< 6.25	< 6.25	
Thallium (Tl)	37.68	14.68	2.94		< 0.190	20.00	< 23.75	< 23.75	< 23.75	
Zinc (Zn)	173.60	1903.95	247.46	1000	6.880	10863.01	< 3.13	148.08	24.05	
Bismuth (Bi)							392691.60	8870.89	1766.67	
Calcium (Ca)							9.84	592.71	439444.70	
Magnesium (Mg)							168.39	6134.55	3580.27	
Strontium (Sr)							32.10	473288.55	325.33	
Tellurium (Te)							< 5.00	50.00	50.00	

a - The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b - Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since contribution is negligible

Table 4.12

RUN #6 METAL FEED CONCENTRATIONS

(parts per million by weight)

Parameter	Soil	Paint	Debris	Capacitors	Liquid Feed	Telurium Slag	Bismuth Slag	Strontium Spike	Magnesium Spike	Mercury Spike
Silver (Ag)	< 0.005	< 0.055	< 0.01		< 0.005	16.44	1.82	< 0.62	2.89	
Arsenic (As)	12.09	< 0.005	0.12		2.860	1370.65	< 6.88	< 6.88	< 6.88	
Barium (Ba)	202.31	744.213	3704.13		0.770	2.50	2.77	44565.82	3.71	
Beryllium (Be)	0.3771	0.05208	< 0.01		< 0.005	0.50	< 0.63	< 0.63	< 0.63	
Cadmium (Cd)	1.355	1.42792	0.16		< 0.005	33.07	< 0.63	< 0.63	< 0.63	
Chromium (Cr)	658.03	13.93	369.16	18000 a	0.590	7.63	12156.16	161.54	2.08	
Copper (Cu)	54.353	8.73792	18.60	9000 b	0.630	5085.13	< 1.88	15.34	< 1.88	
Mercury (Hg)	3.1958	29.6383	1.63		< 0.070	2.50	95.32	8.75	27.67	1000000
Manganese (Mn)	143.18	52.1308	562.65		0.560	5.48	< 0.63	14.79	178.28	
Nickel (Ni)	5.4	3.81917	14.55		< 0.010	13832.29	< 1.25	< 1.25	< 1.25	
Lead (Pb)	39.445	49.8992	4475.67	12000	3.910	114831.70	< 5.00	48.55	< 5.00	
Antimony (Sb)	< 0.11	< 0.11	0.26	500	< 0.110	147509.79	< 13.75	56.38	13.75	
Selenium (Se)	< 0.05	< 0.05	0.12		< 0.050	2945.01	< 6.25	< 6.25	< 6.25	
Thallium (Tl)	15.912	12.8	0.44		< 0.190	20.00	< 23.75	< 23.75	< 23.75	
Zinc (Zn)	244.61	1748.08	19226.55	1000	6.880	10863.01	< 3.13	148.08	24.05	
Bismuth (Bi)						150.00	392691.60	8870.89	1766.67	
Calcium (Ca)						865.81	9.84	592.71	439444.70	
Magnesium (Mg)						308.52	168.39	6134.55	3580.27	
Strontium (Sr)						13.82	32.10	473288.55	325.33	
Tellurium (Te)						77399.91	< 5.00	50.00	50.00	

a The chromium content of shredded capacitors depends on the construction material of the casing. The maximum using stainless steel casing is 18,000 ppm.

b Assuming all aluminum windings.

Note: Aqueous liquid is not included in table since contribution is negligible

Table 4.13

RUN #1 SUMMARY OF WASTE METAL FEED RATE

(average pounds per hour)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.0000	0.0000		0.0000	0.0027	0.0000	0.0000	0.0000		**0.0029**
Arsenic (As)	0.0000	0.0000		0.0205	1.3509	0.0001	0.0001	0.0001		**1.3717**
Barium (Ba)	0.0448	0.1265		0.0015	0.0000	0.0000	0.6391	0.0001		**0.8120**
Beryllium (Be)	0.0005	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000		**0.0006**
Cadmium (Cd)	0.0014	0.0000		0.0000	0.0002	0.0000	0.0000	0.0000		**0.0016**
Chromium (Cr)	0.0058	0.0026	47.9302	0.0000	0.0006	0.1743	0.0023	0.0000		**48.1159**
Copper (Cu)	0.3781	0.0014	23.9651	0.0026	0.0211	0.0000	0.0002	0.0000		**24.3686**
Mercury (Hg)	0.0000	0.0002		0.0003	0.0001	0.0014	0.0001	0.0004	1.5384	**1.5409**
Manganese (Mn)	0.2019	0.0694		0.0007	0.0001	0.0000	0.0002	0.0026		**0.2749**
Nickel (Ni)	0.0060	0.0007		0.0000	0.0026	0.0000	0.0000	0.0000		**0.0095**
Lead (Pb)	0.0179	0.0047	31.9535	0.0028	4.6969	0.0001	0.0007	0.0001		**36.6766**
Antimony (Sb)	0.0001	0.0000	1.3314	0.0005	0.4943	0.0002	0.0008	0.0002		**1.8275**
Selenium (Se)	0.0000	0.0000		0.0002	0.0011	0.0001	0.0001	0.0001		**0.0017**
Thallium (Tl)	0.0179	0.0007		0.0031	0.0003	0.0003	0.0003	0.0003		**0.0230**
Zinc (Zn)	0.1620	0.1505	2.6628	0.0072	0.8502	0.0000	0.0021	0.0003		**3.8352**
Bismuth (Bi)					0.0018	5.6316	0.1272	0.0253		**5.7860**
Calcium (Ca)					0.0104	0.0001	0.0085	6.3021		**6.3211**
Magnesium (Mg)					0.0043	0.0024	0.0880	0.0513		**0.1460**
Strontium (Sr)					0.0000	0.0005	6.7875	0.0047		**6.7926**
Tellurium (Te)					0.0095	0.0001	0.0007	0.0007		**0.0110**

Table 4.14

RUN #2 SUMMARY OF WASTE METAL FEED RATE

(average pounds per hour)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.0043	0.0000		0.0000	0.0028	0.0000	0.0000	0.0000		**0.0072**
Arsenic (As)	0.0000	0.0000		0.0296	1.3876	0.0001	0.0001	0.0001		**1.4175**
Barium (Ba)	0.0348	0.1869		0.0022	0.0000	0.0000	0.6565	0.0001		**0.8804**
Beryllium (Be)	0.0723	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000		**0.0724**
Cadmium (Cd)	0.0032	0.0000		0.0000	0.0002	0.0000	0.0000	0.0000		**0.0035**
Chromium (Cr)	0.0108	0.0005	49.0436	0.0000	0.0006	0.1756	0.0024	0.0000		**49.2337**
Copper (Cu)	0.3428	0.0004	24.5218	0.0038	0.0217	0.0000	0.0002	0.0000		**24.8907**
Mercury (Hg)	0.0002	0.0000		0.0004	0.0001	0.0014	0.0001	0.0004	1.9489	**1.9516**
Manganese (Mn)	0.1721	0.0204		0.0010	0.0001	0.0000	0.0002	0.0026		**0.1963**
Nickel (Ni)	0.0063	0.0002		0.0001	0.0027	0.0000	0.0000	0.0000		**0.0094**
Lead (Pb)	0.0255	0.0013	32.6958	0.0040	4.8246	0.0001	0.0007	0.0001		**37.5519**
Antimony (Sb)	0.0001	0.0000	1.3623	0.0007	0.5078	0.0002	0.0008	0.0002		**1.8721**
Selenium (Se)	0.0168	0.0000		0.0003	0.0012	0.0001	0.0001	0.0001		**0.0185**
Thallium (Tl)	0.0127	0.0000		0.0044	0.0003	0.0003	0.0003	0.0003		**0.0185**
Zinc (Zn)	0.1302	0.0089	2.7246	0.0104	0.8733	0.0000	0.0022	0.0004		**3.7500**
Bismuth (Bi)					0.0018	5.6734	0.1307	0.0260		**5.8320**
Calcium (Ca)					0.0104	0.0001	0.0087	6.4734		**6.4927**
Magnesium (Mg)					0.0043	0.0024	0.0904	0.0527		**0.1498**
Strontium (Sr)					0.0000	0.0005	6.9720	0.0048		**6.9772**
Tellurium (Te)					0.0095	0.0001	0.0007	0.0007		**0.0110**

Table 4.15

RUN #3 SUMMARY OF WASTE METAL FEED RATE

(average pounds per hour)

Parameter	Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.0000	0.0000		0.0000	0.0030	0.0000	0.0000	0.0000		**0.0031**
Arsenic (As)	0.0040	0.0000		0.0205	1.4660	0.0001	0.0001	0.0001		**1.4908**
Barium (Ba)	0.1710	0.1435		0.0015	0.0000	0.0000	0.6936	0.0001		**1.0097**
Beryllium (Be)	0.0010	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000		**0.0011**
Cadmium (Cd)	0.0020	0.0000		0.0000	0.0002	0.0000	0.0000	0.0000		**0.0022**
Chromium (Cr)	0.1360	0.0009	50.5013	0.0000	0.0007	0.1892	0.0025	0.0000		**50.8307**
Copper (Cu)	0.0540	0.0005	25.2507	0.0026	0.0229	0.0000	0.0002	0.0000		**25.3310**
Mercury (Hg)	0.0010	0.0001		0.0003	0.0001	0.0015	0.0001	0.0004	2.0590	**2.0625**
Manganese (Mn)	0.0600	0.0385		0.0007	0.0001	0.0000	0.0002	0.0028		**0.1023**
Nickel (Ni)	0.0080	0.0001		0.0000	0.0028	0.0000	0.0000	0.0000		**0.0111**
Lead (Pb)	0.0340	0.0019	33.6676	0.0027	5.0971	0.0001	0.0008	0.0001		**38.8042**
Antimony (Sb)	0.0000	0.0000	1.4028	0.0005	0.5364	0.0002	0.0009	0.0002		**1.9411**
Selenium (Se)	0.0000	0.0000		0.0002	0.0012	0.0001	0.0001	0.0001		**0.0018**
Thallium (Tl)	0.0350	0.0006		0.0031	0.0003	0.0004	0.0004	0.0004		**0.0401**
Zinc (Zn)	0.0640	0.0492	2.8056	0.0072	0.9227	0.0000	0.0023	0.0004		**3.8513**
Bismuth (Bi)						6.1114	0.1381	0.0275		**6.2770**
Calcium (Ca)						0.0002	0.0092	6.8390		**6.8484**
Magnesium (Mg)						0.0026	0.0955	0.0557		**0.1538**
Strontium (Sr)						0.0005	7.3657	0.0051		**7.3713**
Tellurium (Te)						0.0001	0.0008	0.0008		**0.0016**

Table 4.16

RUN #4 SUMMARY OF WASTE METAL FEED RATE

(average pounds per hour)

Parameter	Soil	Paint	Paint & Soil	Debris	Capacitors	Liquid Feed	Caustic Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.00000	0.00001	0.00000	0.00001		0.00003	0.00026	0.00003	0.00001	0.00003		0.00039
Arsenic (As)	0.00002	0.00001	0.00001	0.00000		0.00926	0.02161	0.00011	0.00011	0.00008		0.03122
Barium (Ba)	0.04787	0.11443	0.07481	0.05489		0.00249	0.00004	0.00004	0.70277	0.00004		0.99739
Beryllium (Be)	0.00033	0.00000	0.00000	0.00000		0.00003	0.00001	0.00001	0.00001	0.00001		0.00040
Cadmium (Cd)	0.00106	0.00018	0.00009	0.00002		0.00003	0.00052	0.00001	0.00001	0.00001		0.00193
Chromium (Cr)	0.10934	0.00112	0.00382	0.00065	20.562	0.00191	0.00012	0.19169	0.00255	0.00003		20.87277
Copper (Cu)	0.07740	0.00110	0.00086	0.00022	10.281	0.00204	0.08019	0.00003	0.00024	0.00002		10.44288
Mercury (Hg)	0.00002	0.00377	0.00209	0.00005		0.00045	0.00004	0.00150	0.00014	0.00028	2.086	2.09461
Manganese (Mn)	0.10222	0.00407	0.00423	0.01243		0.00181	0.00009	0.00001	0.00023	0.00226		0.12735
Nickel (Ni)	0.00460	0.00140	0.00033	0.00003		0.00006	0.21812	0.00002	0.00002	0.00002		0.22461
Lead (Pb)	0.02706	0.00521	0.01886	0.00089	13.708	0.01266	1.81081	0.00008	0.00077	0.00006		15.58409
Antimony (Sb)	0.00003	0.00003	0.00001	0.00001	0.571	0.00071	2.32612	0.00022	0.00089	0.00017		2.89934
Selenium (Se)	0.00002	0.00001	0.00001	0.00000		0.00032	0.04644	0.00009	0.00009	0.00008		0.04707
Thallium (Tl)	0.01574	0.00196	0.00213	0.00036		0.00123	0.00032	0.00038	0.00038	0.00029		0.02278
Zinc (Zn)	0.09820	0.25674	0.25773	0.03004	1.142	0.02228	0.17130	0.00005	0.00234	0.00030		1.98128
Bismuth (Bi)							0.00237	6.19244	0.13989	0.02184		6.35653
Calcium (Ca)							0.01365	0.00016	0.00935	5.52081		5.54397
Magnesium (Mg)							0.00487	0.00266	0.09674	0.04274		0.14700
Strontium (Sr)							0.00022	0.00051	7.46340	0.00405		7.46817
Tellurium (Te)							1.22054	0.00001	0.00079	0.00062		1.22195

Table 4.17

RUN #5 SUMMARY OF WASTE METAL FEED RATE

(average pounds per hour)

Parameter	Soil	Paint	Debris	Capacitors	Blend Liquid	Tellurium Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.00000	0.00003	0.00000		0.00003	0.00011	0.00002	0.00001	0.00004		
Arsenic (As)	0.00453	0.00001	0.00000		0.00950	0.00901	0.00009	0.00009	0.00010		0.02333
Barium (Ba)	0.09559	0.02122	0.07117		0.00256	0.00002	0.00004	0.58567	0.00005		0.77631
Beryllium (Be)	0.00024	0.00000	0.00000		0.00003	0.00000	0.00001	0.00001	0.00001		0.00030
Cadmium (Cd)	0.00091	0.00035	0.00000		0.00003	0.00022	0.00001	0.00001	0.00001		0.00154
Chromium (Cr)	0.43346	0.00591	0.00017	18.70226	0.00196	0.00005	0.15975	0.00212	0.00003		19.30570
Copper (Cu)	0.04863	0.02602	0.00011	9.35113	0.00209	0.03341	0.00003	0.00020	0.00003		9.46165
Mercury (Hg)	0.00015	0.00233	0.00000		0.00046	0.00002	0.00125	0.00012	0.00039	1.73864	1.74337
Manganese (Mn)	0.04744	0.02563	0.00804		0.00186	0.00004	0.00001	0.00019	0.00249		0.08569
Nickel (Ni)	0.00430	0.00185	0.00010		0.00007	0.09089	0.00002	0.00002	0.00002		0.09726
Lead (Pb)	0.02038	0.02033	0.00054	12.46817	0.01298	0.75454	0.00007	0.00064	0.00007		13.27772
Antimony (Sb)	0.00004	0.00003	0.00001	0.51951	0.00073	0.96926	0.00018	0.00074	0.00019		1.49069
Selenium (Se)	0.00002	0.00001	0.00000		0.00033	0.01935	0.00008	0.00008	0.00009		0.01996
Thallium (Tl)	0.01242	0.00387	0.00001		0.00126	0.00013	0.00032	0.00032	0.00033		0.01866
Zinc (Zn)	0.05393	0.42058	0.00307	1.03901	0.02284	0.07138	0.00004	0.00195	0.00034		1.61315
Bismuth (Bi)						0.00099	5.16063	0.11658	0.02469		5.30288
Calcium (Ca)						0.00569	0.00013	0.00779	6.14071		6.15432
Magnesium (Mg)						0.00203	0.00221	0.08062	0.05003		0.13489
Strontium (Sr)						0.00009	0.00042	6.21981	0.00455		6.22487
Tellurium (Te)						0.50858	0.00001	0.00066	0.00070		0.50994

Table 4.18

RUN #6 SUMMARY OF WASTE METAL FEED RATE

(average pounds per hour)

Parameter	Soil	Paint	Debris	Capacitors	Blend Liquid	Tellurium Slag	Bismuth Spike	Strontium Spike	Magnesium Spike	Mercury Spike	Sum of Feeds
Silver (Ag)	0.00000	0.00000	0.00000		0.00003	0.00011	0.00003	0.00001	0.00004		**0.00022**
Arsenic (As)	0.00446	0.00002	0.00000		0.00955	0.00949	0.00010	0.00010	0.00010		**0.02381**
Barium (Ba)	0.07470	0.20609	0.16462		0.00257	0.00002	0.00004	0.61707	0.00005		**1.06515**
Beryllium (Be)	0.00014	0.00001	0.00000		0.00003	0.00000	0.00001	0.00001	0.00001		**0.00022**
Cadmium (Cd)	0.00050	0.00040	0.00001		0.00003	0.00023	0.00001	0.00001	0.00001		**0.00120**
Chromium (Cr)	0.24297	0.00386	0.03318	18.27692	0.00197	0.00005	0.16832	0.00224	0.00003		**18.72966**
Copper (Cu)	0.02007	0.00242	0.00057	9.13846	0.00210	0.03520	0.00003	0.00021	0.00003		**9.19746**
Mercury (Hg)	0.00118	0.00821	0.00005		0.00047	0.00002	0.00132	0.00012	0.00039	1.83185	**1.84500**
Manganese (Mn)	0.05286	0.01444	0.01788		0.00187	0.00004	0.00001	0.00020	0.00249		**0.08799**
Nickel (Ni)	0.00199	0.00106	0.00055		0.00007	0.09576	0.00002	0.00002	0.00002		**0.11247**
Lead (Pb)	0.01456	0.01382	0.20279	12.18462	0.01305	0.79499	0.00007	0.00067	0.00007		**13.21192**
Antimony (Sb)	0.00004	0.00003	0.00001	0.50769	0.00073	1.02122	0.00019	0.00078	0.00019		**1.53143**
Selenium (Se)	0.00002	0.00001	0.00000		0.00033	0.02039	0.00008	0.00008	0.00009		**0.04364**
Thallium (Tl)	0.00588	0.00354	0.00002		0.00127	0.00014	0.00033	0.00033	0.00033		**0.01057**
Zinc (Zn)	0.09032	0.48408	0.73704	1.01538	0.02296	0.07521	0.00004	0.00205	0.00034		**2.40446**
Bismuth (Bi)						0.00104	5.43727	0.12283	0.02469		**5.58582**
Calcium (Ca)						0.00599	0.00014	0.00821	6.14071		**6.15505**
Magnesium (Mg)						0.00214	0.00233	0.08494	0.05003		**0.13944**
Strontium (Sr)						0.00010	0.00044	6.55323	0.00455		**6.55831**
Tellurium (Te)						0.53585	0.00001	0.00069	0.00070		**0.53724**

Table 4.19

Condition 1 Output Concentrations
Average Concentration of Metal in Stream

Condition 1	Kiln Quenched Slag	Dry Scrubber Ash	Wet Scrubber Brine # I	Stack Air Emission
Units of Measure	µg/g	µg/g	mg/l	µg/dscm
Antimony (Sb)	< 110.0	191.8	< 0.11	30.20
Arsenic (As)	< 55.0	325.8	< 0.055	1.58
Barium (Ba)	450.3	78.5	0.11	4.07
Beryllium (Be)	< 5.0	< 0.6	< 0.005	< 0.073
Cadmium (Cd)	18.3	15.1	< 0.005	2.98
Chromium (Cr)	3310.2	89.2	0.88	6.78
Copper (Cu)	17740.8	6178.8	8.06	10.00
Lead (Pb)	221.5	6406.6	2.14	4.44
Mercury (Hg)	97.2	< 8.8	36.48	208.00
Manganese (Mn)	1185.2	65.8	0.16	< 0.338
Nickel (Ni)	1061.2	13.2	0.22	3.54
Selenium (Se)	< 50.0	7.4	< 0.050	
Silver (Ag)	< 5.0	26.6	< 0.005	< 2.005
Tellurium (Te)	< 50.0	< 6.3	< 0.050	*
Thallium (Tl)	< 190.0	< 23.8	< 0.190	14.30
Zinc (Zn)	351.1	4120.7	1.77	47.00
Bismuth (Bi)	57494.8 **	2839.5 **	0.27	135.00
Calcium (Ca)	17697.9	4454.7	75.90	*
Magnesium (Mg)	2211.8	432.8	12.10	101.00
Strontium (Sr)	444.6	781.5	0.31	0.36

* Assay not taken

** Assay suspect

Note: "<" indicates a non-detect level divided by

Table 4.20

Condition 2 Output Concentrations
Average Concentration of Metal in Stream

Condition 2	**Kiln Quenched Slag**	**Dry Scrubber Ash**	**Wet Scrubber Brine # I**	**Stack Air Emission**
Units of Measure	µg/g	µg/g	mg/l	µg/dscm
Antimony (Sb)	< 110.0	208.7	< 0.110	24.80
Arsenic (As)	< 55.0	64.1	< 0.055	0.11
Barium (Ba)	1278.4	103.0	0.16	2.18
Beryllium (Be)	< 5.0	< 0.6	< 0.005	< 0.072
Cadmium (Cd)	29.5	11.4	< 0.005	1.74
Chromium (Cr)	10115.5	62.8	4.69	4.08
Copper (Cu)	19139.9	8390.6	1.19	13.10
Lead (Pb)	210.6	5638.8	1.05	27.80
Mercury (Hg)	< 70.0	< 8.4	88.25	15.30
Manganese (Mn)	2825.2	97.6	0.01	< 9.250
Nickel (Ni)	1887.2	35.7	0.73	8.65
Selenium (Se)	50.0	< 6.0	< 0.050	0.00
Silver (Ag)	21.1	23.5	< 0.005	< 1.980
Tellurium (Te)	< 50.0	371.9	< 0.050	
Thallium (Tl)	< 190.0	< 22.9	< 0.190	47.00
Zinc (Zn)	681.3	4299.4	0.71	0.34
Bismuth (Bi)	176728.5	1990.4	102.58	135.00
Calcium (Ca)	25377.7	3332.3	63.30	***
Magnesium (Mg)	3975.9	458.7	9.03	101.00
Strontium (Sr)	1158.5	501.9	0.13	< 5.050

* Assay not taken
** Assay suspect

Note: "<" indicates a non-detect level divided by 2

Table 4.21

CONDITION I OUTPUT MASS RATE
Average Pounds Per Hour Of Metals In Streams

Condition 1	Kiln Quenched Slag	Dry Scrubber Ash	Wet Scrubber Brine # I	Stack Air Emission
Units of Measure	µg/g	µg/g	mg/l	µg/dscm
Antimony (Sb)	< 0.570	0.255	< 0.00000	0.00378
Arsenic (As)	< 0.285	0.421	< 0.00000	0.00020
Barium (Ba)	2.267	0.101	0.00494	0.00051
Beryllium (Be)	< 0.026	< 0.001	< 0.00000	< 0.00001
Cadmium (Cd)	0.096	0.020	< 0.00000	0.00037
Chromium (Cr)	16.657	0.116	0.00572	0.00086
Copper (Cu)	86.242	8.043	-0.55535	0.00126
Lead (Pb)	1.187	8.285	-0.23815	0.00056
Mercury (Hg)	< 0.536	< 0.011	0.46747	0.02684
Manganese (Mn)	5.785	0.085	0.00234	< 0.00004
Nickel (Ni)	5.234	0.017	0.00104	0.00044
Selenium (Se)	< 0.259	0.010	< 0.00000	0.00000
Silver (Ag)	< 0.026	0.037	< 0.00000	< 0.00026
Tellurium (Te)	< 0.259	< 0.008	< 0.00000	
Thallium (Tl)	< 0.984	< 0.031	< 0.00000	0.00179
Zinc (Zn)	1.826	5.418	-0.20487	0.00570
Bismuth (Bi)	314.572	3.668	1.22483	0.01709
Calcium (Ca)	95.329	5.695	-2.16835	
Magnesium (Mg)	11.842	0.558	-0.25219	0.01263
Strontium (Sr)	2.091	1.007	-0.01456	0.00005
Total Wgt. /Stream	546.072	33.787	-1.727137	0.0723976
Total All Streams				578.20

Note: "<" indicates a non-detect level divided by 2
"-" indicates a decrease of concentration in Brine

Table 4.22

CONDITION 2 OUTPUT MASS RATE

Average Pounds Per Hour Of Metals In Streams

Condition 2	Kiln Quenched Slag	Dry Scrubber Ash	Wet Scrubber Brine # I	Stack Air Emission
Units of Measure	µg/g	µg/g	mg/l	µg/dscm
Antimony (Sb)	< 0.390	0.315	< 0.0047	0.0031
Arsenic (As)	< 0.195	0.097	< 0.0024	0.00001
Barium (Ba)	4.666	0.156	0.0069	0.0003
Beryllium (Be)	< 0.018	< 0.001	< 0.0002	< 0.00001
Cadmium (Cd)	0.100	0.017	< 0.0002	0.0002
Chromium (Cr)	35.247	0.095	0.2011	0.0005
Copper (Cu)	67.278	12.663	0.0511	0.0017
Lead (Pb)	0.879	8.510	0.0451	0.0035
Mercury (Hg)	< 0.248	< 0.013	3.7877	0.0019
Manganese (Mn)	9.885	0.147	0.0002	< 0.00110
Nickel (Ni)	6.455	0.054	0.0313	0.0011
Selenium (Se)	< 0.177	< 0.009	< 0.0021	0.0000
Silver (Ag)	0.087	0.035	< 0.0002	< 0.00025
Tellurium (Te)	< 0.177	0.561	< 0.0021	0.0000
Thallium (Tl)	< 0.673	< 0.034	< 0.0082	0.0059
Zinc (Zn)	2.445	6.489	0.0305	0.0000
Bismuth (Bi)	620.313 *	3.004	4.4027	0.0171
Calcium (Ca)	94.008	5.029	2.7168	
Magnesium (Mg)	15.353	0.692	0.3876	0.0127
Strontium (Sr)	4.079	0.758	0.0056	< 0.00063
Total Wgt. /Stream	862.673	38.680	11.6866	0.0521
Total All Streams				913.0918

Note: "<" indicates a non-detect level divided by 2
"-" indicates a decrease of concentration in Brine

Table 4.23

CONDITION #1
AVERAGE METALS CONCENTRATIONS FOR BRINE SAMPLES

Stream Number	10	11	12	13	14	15	16
Sample	Brine Make-up*	Brine # I	Brine Rundown**	Brine # II	Brine # III	Brine #III Feed	Make-up Water
Units of Measure	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Silver (Ag)	0.013	< 0.005	0.030	0.063	0.037	< 0.005	< 0.005
Arsenic (As)	< 0.055	< 0.055	< 0.055	< 0.055	< 0.055	< 0.055	< 0.055
Barium (Ba)	0.025	0.105	0.127	0.227	0.265	0.233	0.080
Beryllium (Be)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium (Cd)	< 0.005	< 0.005	0.017	0.010	0.010	0.008	< 0.005
Chromium (Cr)	0.028	0.878	0.200	0.042	0.087	0.018	< 0.005
Copper (Cu)	5.450	8.063	8.203	7.990	4.247	7.788	< 0.015
Mercury (Hg)	36.312	36.483	26.077	1.397	0.163	< 0.070	< 0.070
Manganese (Mn)	0.005	0.155	0.050	0.093	0.100	0.118	0.009
Nickel (Ni)	0.010	0.217	0.097	0.073	0.070	0.037	< 0.010
Lead (Pb)	1.230	2.140	3.140	4.823	1.887	3.002	< 0.040
Antimony (Sb)	< 0.110	< 0.110	< 0.110	< 0.110	< 0.110	< 0.110	< 0.110
Selenium (Se)	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Tellurium (Te)	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Thallium (Tl)	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190
Zinc (Zn)	1.557	1.770	3.153	2.840	1.573	3.857	0.025
Bismuth (Bi)	< 0.265	< 0.265	5.747	< 0.265	< 0.265	< 0.265	< 0.265
Calcium (Ca)	25.425	75.903	68.467	160.880	202.957	263.205	78.869
Magnesium (Mg)	10.400	12.103	11.273	21.487	27.070	34.380	10.091
Strontium (Sr)	0.080	0.312	0.252	1.037	1.360	1.938	0.536

* Brine Make-up is a slip stream that crystaline soda ash is added to.

** Brine Rundown is the sump pump discharge to the neutralization tanks.

*** Brine #III Feed is the liquid feed to the brine circuit cooling tower blow down.

Note: "<" indicates a non detectable number reported as 1/2 the detection limit.

Table 4.24

CONDITION #2
AVERAGE METALS CONCENTRATIONS FOR BRINE SAMPLES

Stream Number	10.000	11.000	12.000	13.000	14.000	15.000	16.000
Sample	Brine Make-up*	Brine # I	Brine Rundown**	Brine # II	Brine # III	Brine #III Feed	Make-up Water
Units of Measure	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
Silver (Ag)	< 0.005	< 0.005	< 0.005	0.067	0.025	0.008	< 0.005
Arsenic (As)	< 0.055	< 0.055	< 0.055	< 0.055	< 0.055	< 0.055	< 0.055
Barium (Ba)	0.038	0.147	0.150	0.217	0.230	0.412	0.084
Beryllium (Be)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium (Cd)	< 0.005	< 0.005	< 0.005	< 0.005	0.010	0.006	< 0.005
Chromium (Cr)	1.042	1.653	1.717	0.133	0.143	0.023	< 0.005
Copper (Cu)	3.560	4.270	4.287	8.853	5.380	5.957	< 0.015
Mercury (Hg)	51.172	59.147	59.627	7.487	1.240	0.082	< 0.070
Manganese (Mn)	0.021	0.045	0.023	0.037	0.005	0.037	0.006
Nickel (Ni)	0.010	0.170	0.263	0.050	0.073	0.015	< 0.010
Lead (Pb)	1.627	2.510	2.737	9.687	3.073	3.238	0.036
Antimony (Sb)	< 0.110	< 0.110	< 0.110	< 0.110	< 0.110	< 0.110	< 0.110
Selenium (Se)	< 0.050	< 0.050	< 0.050 #	< 0.050	< 0.050	< 0.050	< 0.050
Tellurium (Te)	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Thallium (Tl)	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190	< 0.190
Zinc (Zn)	0.873	1.777	1.677	1.773	3.107	2.180	0.072
Bismuth (Bi)	18.182	42.323	54.170	10.855	10.213	< 0.265	< 0.265
Calcium (Ca)	29.417	75.903	73.870	130.317	168.557	234.248	82.099
Magnesium (Mg)	11.162	10.913	10.637	18.763	24.907	34.458	10.584
Strontium (Sr)	0.005	0.165	0.252	0.947	0.990	1.545	0.211

* Brine Make-up is a slip stream that crystaline soda ash is added to.

** Brine Rundown is the sump pump discharge to the neutralization tanks.

*** Brine #III Feed is the liquid feed to the brine circuit cooling tower blow down.

Note: "<" indicates a non detectable number reported as 1/2 the detection limit.

Table 4.25

CONDITION 1 MASS RATES/PARTITIONING

Parameter	Kiln Feeds	Kiln Slag	Afterburner Flue Gas	Dry Scrubber Ash & Solids	Baghouse Flue Gas	Wet Scrubber Brine #I	Stack Emission
Rate - Lb/hr						450656 lbs *	
Units of Measure	*Lbs/Hr*	*Lbs/Hr*	*Lbs/hr*	*Lbs/Hr*	*Lbs/hr*	*Lbs/Hr*	*Lbs/Hr*
Antimony (Sb)	1.8655	< 0.5697	0.6636	0.2549	0.0039	0.00000	0.00379
Arsenic (As)	1.4160	< 0.2849	0.9105	0.4207	0.0001	0.00000	0.00020
Barium (Ba)	.8973	2.2674	0.0567	0.1013	0.0003	0.00494	0.00052
Beryllium (Be)	.0285	< 0.0259	< 0.0001	< 0.0008	0.0000	0.00000	< 0.00001
Cadmium (Cd)	.0025	0.0959	0.0215	0.0198	0.0002	0.00000	0.00037
Chromium (Cr)	49.0150	16.6566	0.1224	0.1155	0.0007	0.00572	0.00086
Copper (Cu)	24.6735	86.2420	6.5388	8.0426	0.0015	-0.55535	0.00126
Lead (Pb)	37.3826	1.1865	5.2910	8.2850	0.0003	-0.23815	0.00056
Mercury (Hg)	1.7133	< 0.5360	1.4352	< 0.0114	1.3779	0.46747	0.02690
Manganese (Mn)	.1874	5.7850	< 0.0842	0.0853	< 0.0005	0.00234	< 0.00009
Nickel (Ni)	.0099	5.2342	0.0324	0.0172	0.0006	0.00104	0.00045
Selenium (Se)	.0081	< 0.2590	0.0011	< 0.0097	0.0002	0.00000	0.00000
Silver (Ag)	.0046	< 0.0259	0.0027	< 0.0370	< 0.0001	0.00000	< 0.00026
Tellurium (Te)	.0079	< 0.2590	0.0000	0.0081	0.0000	0.00000	0.00000
Thallium (Tl)	.0271	< 0.9841	0.0163	0.0308	0.0016	0.00000	0.00179
Zinc (Zn)	2.8492	1.8262	10.3241	5.4182	0.0078	-0.20487	0.00571
Bismuth (Bi)	5.9484	314.5716 **	5.7606	3.6684	0.5688	1.22483	0.01713
Calcium (Ca)	6.4955	95.3288	0.0000	5.6945	0.0000	-2.16835	0.00000
Magnesium (Mg)	.1486	11.8422	0.0351	0.5585	0.0064	-0.25219	0.00644
Strontium (Sr)	6.9840	2.0909	0.5049	1.0070	0.0001	-0.01456	0.00005
Total Wgt. /Stream		**546.0717**		**33.7868**		**-1.72714**	**0.06638**
Total All Streams							**578.19774**

* Is in pounds solution calculated to be in Brine # I circuit
** Mass rate suspect due to suspect high assay
"<" Indicates rate based on a non detect assay of the sample taken

Table 4.26

CONDITION 2 MASS RATES/PARTITIONING

Parameter	Kiln Feeds	Kiln Slag	Afterburner Flue Gas	Dry Scrubber Ash & Solids	Baghouse Flue Gas	Wet Scrubber Brine #I	Stack Emission
Rate - Lb/hr							
Units of Measure	*Lbs/Hr*	*Lbs/Hr*	*Lbs/Hr*	*Lbs/Hr*	*Lbs/Hr*	450656 Lbs *Lbs/Hr*	*Lbs/Hr*
Antimony (Sb)	1.8444	< 0.39	.3461	0.315	.0016	< 0.0047	.00311
Arsenic (As)	0.0233	< 0.19	.0659	0.097	.0000	< 0.0024	.00001
Barium (Ba)	0.9169	4.67	.1219	0.156	.0003	0.0069	.00028
Beryllium (Be)	0.0003	< 0.02	< 0.0000	< 0.001	< 0.0000	< 0.0002	< .00001
Cadmium (Cd)	0.0015	0.10	.0068	0.017	.0003	< 0.0002	.00022
Chromium (Cr)	19.5107	35.25	.0518	0.095	.0001	0.2011	.00051
Copper (Cu)	9.6196	67.28	8.6883	12.663	.0017	0.0511	.00166
Lead (Pb)	13.8182	0.88	4.0829	8.510	.0007	0.0451	.00355
Mercury (Hg)	1.8588	< 0.25	1.2963	< 0.013	2.3766	3.7877	.00108
Manganese (Mn)	0.0966	9.89	.0926	0.147	.0004	0.0002	< 0.00192
Nickel (Ni)	0.1288	6.45	.0483	0.054	.0011	0.0313	.00108
Selenium (Se)	0.0268	< 0.18	.0131	< 0.009	.0001	< 0.0021	.00004
Silver (Ag)	0.0003	0.09	.0038	0.035	.0004	< 0.0002	< 0.00025
Tellurium (Te)	0.6909	< 0.18		0.561		< 0.0021	
Thallium (Tl)	0.0173	< 0.67	1.5212	< 0.034	.0015	< 0.0082	.00589
Zinc (Zn)	1.9443	2.44	4.1446	6.489	.0190	0.0305	.00004
Bismuth (Bi)	5.6441	620.31 *	5.6923	3.004	4.0984	4.4027	.33289
Calcium (Ca)	5.9895	94.01		5.029		2.7168	
Magnesium (Mg)	0.1391	15.35	.0661	0.692	.0071	0.3876	.01265
Strontium (Sr)	6.6275	4.08	.6041	0.758	.0001	0.0056	< 0.00063
Total Wgt. /Strean		**862.67**		**38.680**		**11.6866**	**0.3658**
Total All Streams							**913.4056**

* Is in pounds solution calculated to be in Brine # I circuit

** Mass rate suspect due to suspect high assay

"<" Indicates rate based on a non detect assay of the sample taken

Table 4.27

CONDITION 1
METALS PARTITIONING NORMALIZED ACROSS COMBUSTION SYSTEM
Calculated Percent Removal Based On Unit Outlet Mass Rates

APTUS DATA	Kiln Quenched Slag	Dry Scrubber Ash	Wet Scrubber Brine # I Accumulation	Wet Scrubber Stack Emissions
Antimony (Sb)	46.19%	52.999%	0.000%	0.81%
Arsenic (As)	23.83%	76.144%	0.000%	0.03%
Barium (Ba)	97.56%	2.431%	0.006%	0.00%
Beryllium (Be)	99.69%	0.307%	0.000%	0.01%
Cadmium (Cd)	81.68%	18.135%	0.000%	0.19%
Chromium (Cr)	99.27%	0.725%	0.004%	0.00%
Copper (Cu)	92.95%	7.046%	0.001%	0.00%
Lead (Pb)	18.32%	81.679%	0.003%	0.00%
Mercury (Hg)	27.19%	0.596%	68.284%	3.93%
Manganese (Mn)	98.57%	1.427%	0.008%	0.00%
Nickel (Ni)	99.38%	0.595%	0.014%	0.01%
Selenium (Se)	99.58%	0.412%	0.000%	0.01%
Silver (Ag)	90.59%	9.376%	0.000%	0.03%
Tellurium (Te)	100.00%	0.000%	0.000%	0.00%
Thallium (Tl)	98.37%	1.552%	0.000%	0.08%
Zinc (Zn)	15.03%	84.848%	0.126%	0.00%
Bismuth (Bi)	98.20%	1.557%	0.238%	0.00%
Calcium (Ca)	100.00%	0.000%	0.000%	0.00%
Magnesium (Mg)	99.70%	0.292%	0.003%	0.00%
Strontium (Sr)	80.55%	19.448%	0.002%	0.00%

Partitioning is based on outlet mass rates for each unit normalized by the inlet from the previous unit

Table 4.28
CONDITION 2
METALS PARTITIONING NORMALIZED ACROSS COMBUSTION SYSTEM
Calculated Percent Removal Based On Unit Outlet Mass Rates

APTUS DATA	Kiln Quenched Slag	Dry Scrubber Ash	Wet Scrubber Brine # I Accumulation	Wet Scrubber Stack Emissions
Antimony (Sb)	52.97%	45.96%	0.643%	0.423%
Arsenic (As)	74.73%	25.26%	0.005%	0.000%
Barium (Ba)	97.45%	2.54%	0.005%	0.000%
Beryllium (Be)	99.83%	0.17%	0.001%	0.000%
Cadmium (Cd)	93.60%	6.29%	0.051%	0.052%
Chromium (Cr)	99.85%	0.15%	0.000%	0.000%
Copper (Cu)	88.56%	11.44%	0.001%	0.000%
Lead (Pb)	17.71%	82.28%	0.006%	0.000%
Mercury (Hg)	16.06%	0.45%	83.465%	0.024%
Manganese (Mn)	99.07%	0.93%	0.000%	0.002%
Nickel (Ni)	99.26%	0.73%	0.015%	0.001%
Selenium (Se)	93.11%	6.82%	0.068%	0.001%
Silver (Ag)	95.85%	4.11%	0.020%	0.023%
Tellurium (Te)	100.00%	0.00%	0.000%	0.000%
Thallium (Tl)	30.69%	66.39%	1.696%	1.224%
Zinc (Zn)	37.10%	62.72%	0.184%	0.000%
Bismuth (Bi)	99.09%	0.38%	0.488%	0.037%
Calcium (Ca)		0.00%	100.000%	0.000%
Magnesium (Mg)	99.57%	0.42%	0.004%	0.000%
Strontium (Sr)	87.10%	12.90%	0.001%	0.000%

Partitioning is based on outlet mass rates of each unit normalized by the inlet from the previous unit

5.0 SAMPLING LOCATIONS AND PROCEDURES

Sampling locations and procedures used during the test program conducted at the Aptus facility are described in this section. Standard EPA methods and state-of-the-art procedures for sampling and analysis were used throughout the test program. The sampling matrix and schedule is described in Section 5.1. Sampling locations are discussed in Section 5.2, and sampling methods are described in Section 5.3. The sample collection parameters and sampling conditions are discussed and summarized in Section 5.4.

5.1 Sampling Matrix and Schedule

Two different feed conditions were tested during this program. Triplicate tests for metals, particulate, and HCl were performed at both conditions. Sampling and analysis matrices for each test location are listed in Table 5-1. The testing schedule as executed is shown on Table 5-2. Samples for metals/particulate analyses were collected in a single sampling train and tests were performed simultaneously at the afterburner outlet, baghouse outlet, and outlet stack. Hydrogen chloride tests were performed at the baghouse outlet and the scrubber stack. Process samples of the waste feed, slag, baghouse/spray dryer catch, make-up water, and brine were taken during each test. The process operation was observed during the test by an engineer and data were recorded manually every 30 minutes from strip charts and digital readouts in the control room.

5.2 Sampling Locations

Flue gas sampling took place at three different points in the incinerator and air pollution control train: the afterburner outlet, the baghouse outlet, and the scrubber stack. Descriptions and critical sampling parameters of these locations are provided in the subsequent sections.

5.2.1 Afterburner Outlet

Typically, the inlet to the air pollution control device (APCD) for the Aptus system would be defined as the spray dryer inlet. However, due to obstructions present in the ductwork, samples were taken just upstream of this point in the hot duct at the afterburner outlet. This sampling location was approximately one diameter downstream and approximately 4.5 diameters upstream from flow disturbances as shown in Figure 5-1. The duct ID was 5.5 feet. Access to the flue gases was provided through a single port oriented at approximately 55° from the direction of gas flow. Because of this port angle, a duct traverse could not be completed in a duct cross-sectional plan perpendicular to gas flow. An additional port oriented perpendicular to gas flow could not be constructed because of potential damage to the duct refractory. Therefore, afterburner outlet sampling was conducted through the existing port, at a single point and at a constant sample flow rate (non-isokinetic). A single piece quartz nozzle/probe was used for flue gas extraction. The nozzle was oriented at an angle so that the flue gas flow was perpendicular to the nozzle opening. The sampling point was approximately 1.5 feet inside the afterburner outlet duct.

5.2.2 Baghouse Outlet

The baghouse outlet was sampled in a horizontal run of rectangular (5'x4') duct. Six 3-inch ports, located 12.5 feet downstream of the baghouse outlet and 2.0 feet upstream of the duct expansion, provided access to the gas stream. Five points were sampled in each port, resulting in a 30 point test. Figure 5-2 contains an illustration of this sampling location.

5.2.3 Scrubber Stack

Flue gas samples taken at the scrubber outlet were collected in a stack 42.5 inches in diameter. The sampling location was 24.0 feet downstream of the induced draft fan breeching and 69 feet upstream of atmospheric exhaust. Sample acquisition was accomplished through two 3-inch ports as shown in Figure 5-3.

5.3 Sampling Procedures

Sampling procedures used for this test program are described in this section. Where applicable, EPA standard methods were used. If EPA Reference methods were not available, state-of-the-art methods or technology was applied.

5.3.1 Flue Gas Samples

Flue gas samples were collected at all three locations. Each type of flue gas sample collected during this test program is described in detail in the following sections.

5.3.1.1 Particulate and Trace Metals Sampling Method. Sampling for total particulate matter and toxic metals at the baghouse outlet and the stack was conducted using a modified version of the Method 5 sampling train. This method, entitled "Methodology for the Determination of Trace Metal Emissions in Exhaust Gases from Stationary Source Combustion Processes," has been proposed for acceptance by the EPA, and is currently being validated. A schematic of the sampling train is shown in Figure 5-4.

Due to sample location constraints discussed in Section 5.2, particulate/metals sampling at the afterburner outlet location was conducted non-isokinetically. Sample gas was pulled from a single sample point at approximately 0.25 CFM. A single piece, quartz glass nozzle/probe was used for flue gas extraction. The nozzle opening was approximately one-half inch in diameter and was oriented perpendicular to the flue gas flow. Identical trains were used at the other two sampling locations.

The front half of the sample train was identical to a Method 5 train, utilizing a borosilicate glass, nozzle, probe, and filter holder. A

Teflon-coated screen was used to support the filter and both the probe and filter holder were heated to 248 ± 25°F to prevent moisture condensation. A high purity glass fiber filter without organic binder and with a 99.95 percent collection efficiency on 0.3 micron dioctyl phthalate (DOP) smoke particles was used. Sampling was conducted for 120 minutes.

The back half of the impinger train was modified to capture the metals in the vapor phase. The impingers will be arranged as follows:

1. Empty knock-out impinger (Modified Greenburg-Smith).
2. Greenburg-Smith impinger containing 100 ml of 5% HNO_3 and 10% H_2O_2 solution.
3. Same as Number 2 above.
4. Greenburg-Smith impinger containing 100 ml of acidic $KMNO_4$ solution.
5. Modified Greenburg-Smith impinger containing about 200 grams of indicating silica gel.

An ice bath was used to maintain an impinger exit temperature of ≤68°F. All connections were made with leak-tight, ground glass joints and the glassware used for the particulate/toxic metals train was cleaned according to the procedures outlined in Table 5-3.

With the exception of the afterburner outlet location, the flue gas was withdrawn from the stack isokinetically. At the end of the test run, the train was disassembled into three parts: (1) probe, (2) filter and connecting glassware, and (3) impingers. Each part of the sample train was sealed to prevent sample loss or contamination. These parts of the sample train were transferred to the field laboratory, where they were recovered. A final weight for each impinger was obtained during recovery for moisture determination. The sample train was recovered, as shown in Table 5-4. All sample weights were recorded so that it could be determined if any sample was lost during transport. No sample leakage was observed during or after sample transport.

5.3.1.2 HCl Sampling Method. Flue gases were sampled for HCl concentrations by using state-of-the-art sampling technology. Gases were extracted from the stack at a single location and at a rate of approximately 0.5 CFM. The sample was extracted through a heated glass probe and passed through a heated filter to remove any particulate. A schematic of the HCl sampling train is shown in Figure 5-5. A 0.1 N NaOH collection solution was used in the first two impingers. The third impinger was empty and served as an additional moisture knock-out. The final impinger contained indicating silica gel.

HCl flue gas samples were collected for 60 minutes. The contents of the impingers was recovered into leak tight sample bottle and then weighed so that any sample loss occurring during transport could be determined. For the Aptus/OSW test program, no sample leakage was observed.

5.3.1.3 EPA Methods 1, 2, 3, and 4. EPA Reference Methods 1 through 4 were used to determine the sample traverse point locations, volumetric flow rate, molecular weight, and the gas moisture content. These methods are described in the following paragraphs.

The volumetric gas flow rate was determined during this program using procedures described in EPA Method 2. The volumetric gas flow rate is determine by measuring the cross-sectional area of the duct and the average velocity of the exhaust gas which is calculated from the average pitot tube pressure (P), the average flue gas temperature, wet molecular weight, and the absolute static pressure. Temperature and P profile data were obtained during the metals/particulate duct traverse. The sampling points required to measure the average gas velocity were determined using the procedures outlined in EPA Method 1. The number of sampling points and their distance from the duct wall is a function of the proximity of the sampling location to its nearest upstream and downstream flow disturbance.

Temperature and pressure profile data was measured at each of the sampling points using an S-type pitot tube and K-type thermocouple. An oil manometer of the proper range was used to measure the pressure differential across the S-type pitot. An absolute pressure gauge was used to obtain barometric pressure readings at least once per day. The static gas pressure at the baghouse outlet and stack outlet was measured by disconnecting one side of the S-type pitot and then rotating the pitot so that it is perpendicular to the gas flow.

The integrated sampling technique described in EPA Method 3 was used to obtain a composite exhaust gas sample for fixed gas (O_2, CO_2) analysis. A small diaphragm pump and a stainless steel probe was used to extract a single point flue gas sample, which was collected in a Tedlar bag. Moisture was removed from the gas sample by an ice bath condenser and the composition of the dry gas sample was determined using an Orsat analyzer.

The moisture content of the flue gas was determined using the methodology described in EPA Method 4. Based on this method, a known volume of particulate-free gas is pulled through a chilled impinger train. The quantity of condensed water is determined gravimetrically and then related to the volume of gas sampled to determine the moisture content.

5.3.2 Process Sample and Analysis of Waste Feed and Outfalls

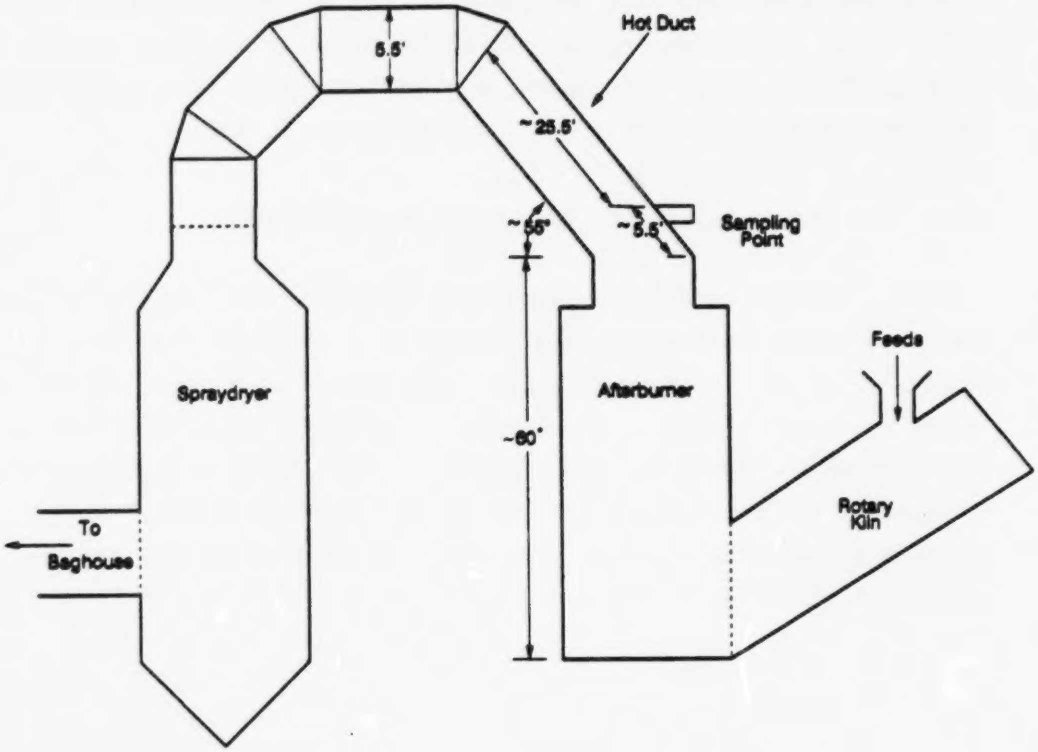
During each test, process samples of the hazardous waste feed, kiln ash, spray dryer/baghouse ash, and selected brine streams were collected. Samples were taken at the beginning of each test and every 30 minutes thereafter, until each test was completed. Samples were placed in glass sample jars with Teflon-lined caps. Table 5-5 indicates the location, sampling method, frequency of sampling, and parameters of analysis for influent and effluent streams. Table 5-6 lists analytical methods and references.

Liquid waste feed to the incinerator was sampled prior to the commencement of each trial burn. The liquid blend tanks are capable of being agitated, either by propeller type mixer or by recirculation. Tanks which were to be sampled were agitated for a period of 20 minutes prior to sampling. Samples were then taken via a spigot on the tank, in accordance with EPA Method S004.

Soils and sludges were fed to the kiln via a drum elevator. A grab sample was taken from each drum that was fed to the incinerator during the trial burn. These samples were then composited to produce a single sample for that particular waste feed during a given run. Slag was sampled at the kiln discharge hopper every 30 minutes during the trial burn.

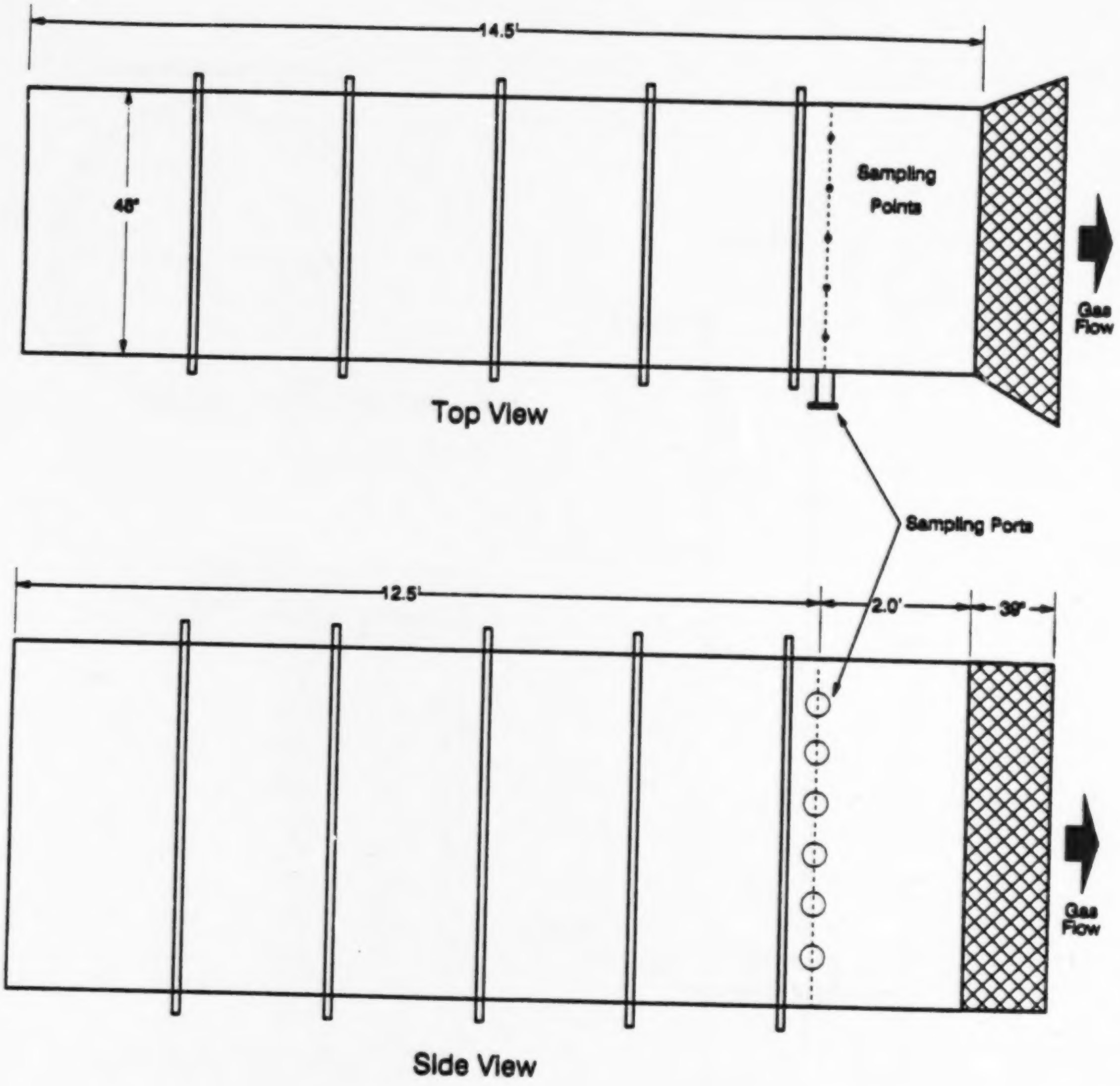
5.4 Sample Collection Parameters and Conditions

Sample collection parameters, gas flow rates, temperatures, and moisture content are summarized in Tables 5-7 and 5-8. The test runs were typically of two hours in duration. The stack temperature, oxygen content, stack moisture content, and volumetric flow rates were consistent among the runs within a condition. The isokinetic sampling rate QC objective of 100 ± 10 percent was not for all runs except the baghouse outlet Run 01. The isokinetic sampling rate for this test run was 89.6 percent (versus the objective of 90 percent).


Hot Duct
5.5'
~25.5'
~55°
~5.5'
Sampling Point
Feeds
Spraydryer
Afterburner
~60'
Rotary Kiln
To Baghouse

2294030R

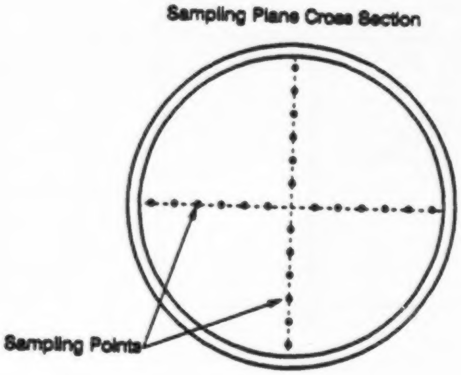
Figure 5-1. Afterburner Exit Sampling Location, Aptus Environmental Coffeeville, KS (April 1989)

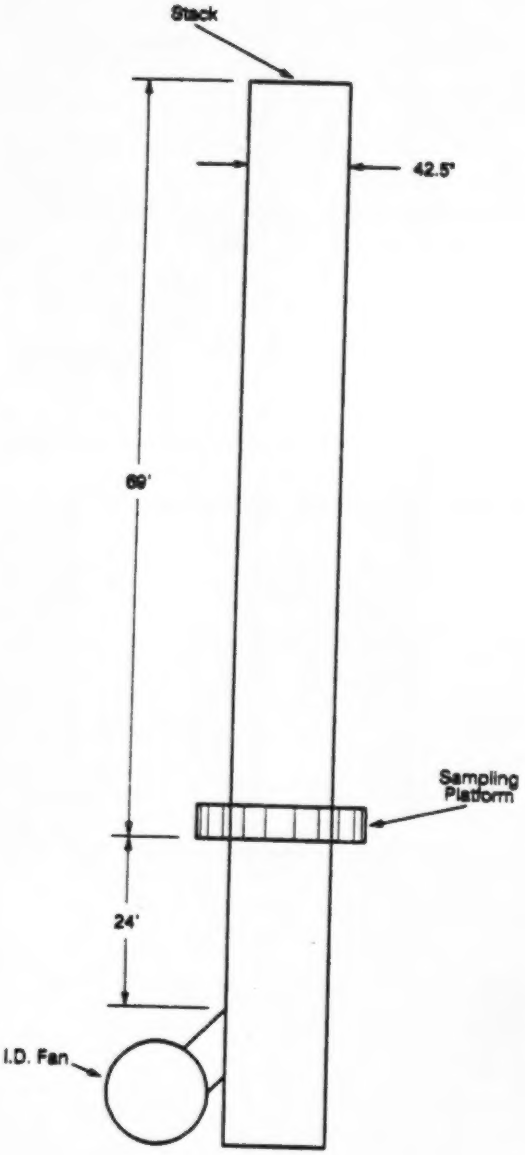

14.5'
48"
Sampling Points
Gas Flow
Top View
Sampling Ports
12.5'
2.0'
39"
Gas Flow
Side View

Point	Inches from Wall
1	4.8
2	14.4
3	24.0
4	33.6
5	43.2

Figure 5-2 Baghouse Outlet Sampling Location

2294034R


Sampling Plane Cross Section
Sampling Points


Stack
42.5"
69'
Sampling Platform
24'
I.D. Fan

Point No.	Percent Diameter	Distance from Wall (In)
1	2.1	1.0
2	6.7	2.8
3	11.8	5.0
4	17.7	7.5
5	25.0	10.6
6	35.6	15.1
7	64.4	27.4
8	75.0	31.9
9	82.3	35.0
10	88.2	37.5
11	93.3	39.7
12	97.9	41.5

2294035R

Figure 5-3 Stack Sampling Location

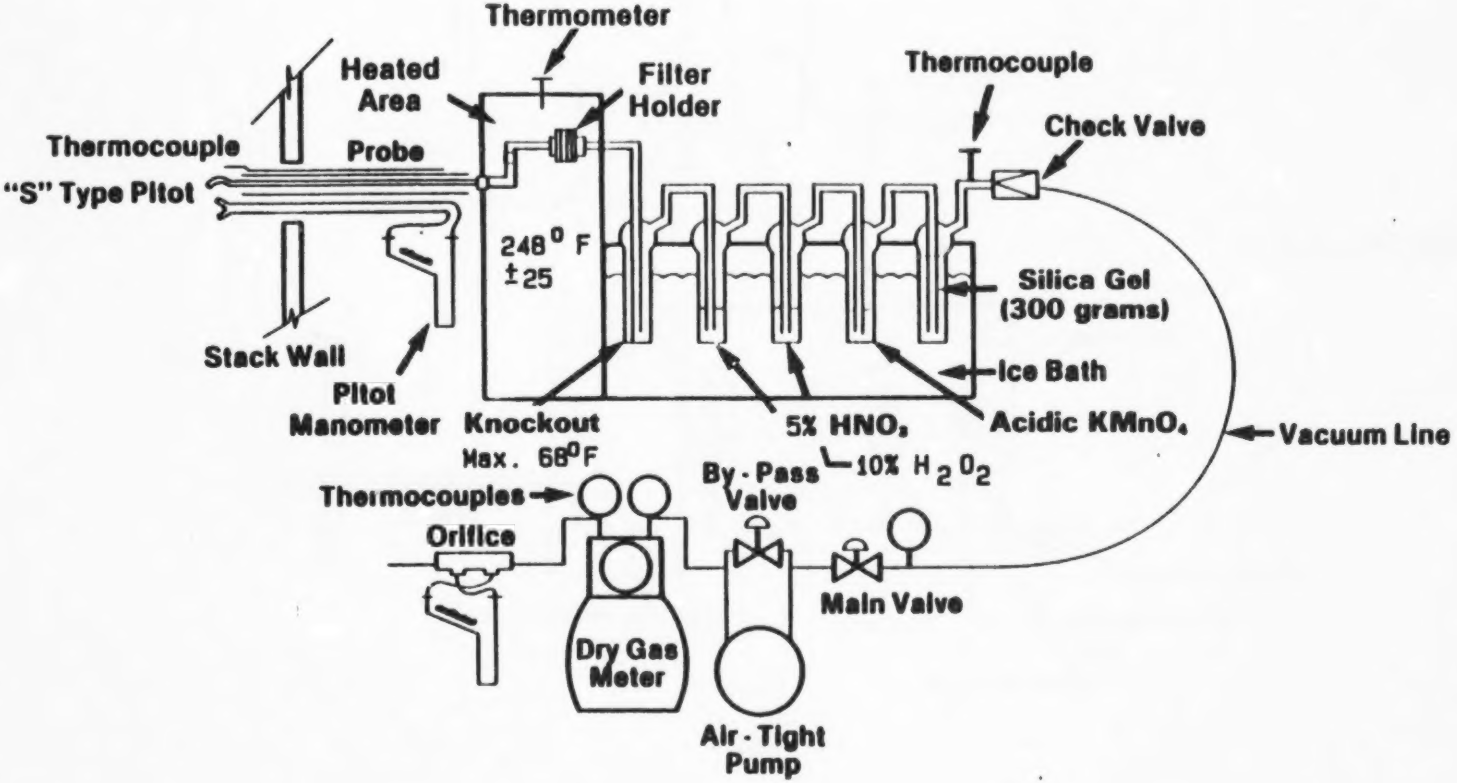

Thermometer
Heated Area
Filter Holder
Thermocouple
Check Valve
Thermocouple
Probe
"S" Type Pitot
248° F ±25
Silica Gel (300 grams)
Stack Wall
Ice Bath
Pitot Manometer
Knockout Max. 68°F
5% HNO₃
Acidic KMnO₄
Vacuum Line
10% H₂O₂
By-Pass Valve
Thermocouples
Orifice
Main Valve
Dry Gas Meter
Air-Tight Pump

Figure 5-4 Schematic of the Toxic Metals/Particulate Sampling Train

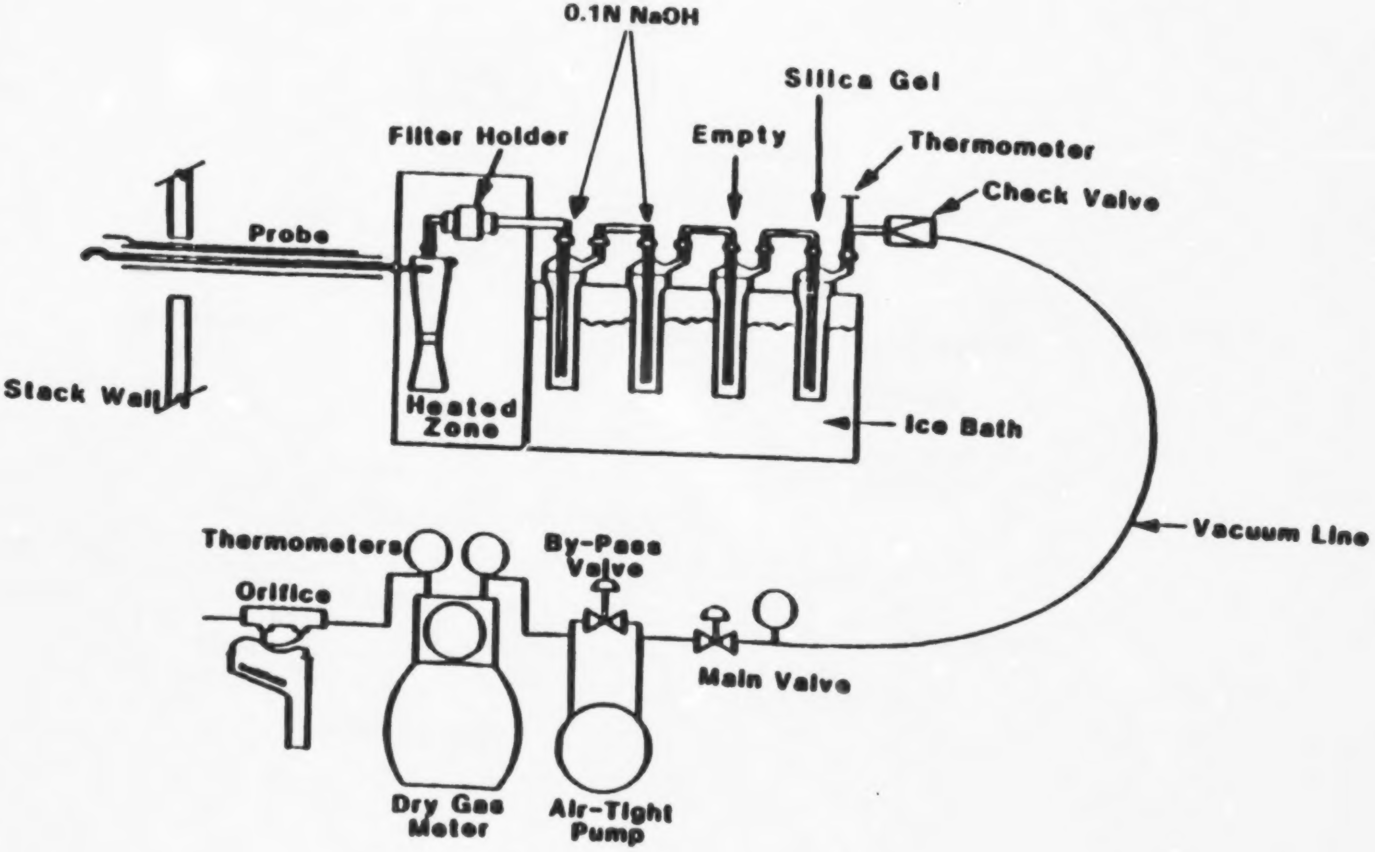

0.1N NaOH
Silica Gel
Filter Holder
Empty
Thermometer
Check Valve
Probe
Stack Wall
Heated Zone
Ice Bath
Vacuum Line
Thermometers
By-Pass Valve
Orifice
Main Valve
Dry Gas Meter
Air-Tight Pump

Figure 5-5 Components of the HCl Sampling Train

TABLE 5-1. SAMPLING AND ANALYTICAL MATRIX

Sampling Location	Analytes Sampled	Sampling Method or Type	Number of Samples	Analytical Method[a]
Afterburner Outlet	Particulate Metals[c]	EMSL Toxic Metals Train	3 tests at each condition	Gravimetric AA/ICAP
	Moisture	EPA Method 4[b]		Gravimetric
	Molecular Weight (O_2, CO_2, N_2)	EPA Method 3[b]		Orsat
	Velocity	EPA Method 1[b] and 2		Pitot Tubes/ Manometer
	Toxic Metals Reagent Blank	EMSL Toxic Metals Train	1	ICAP AA
Baghouse Outlet	Particulate Metals[c]	EMSL Toxic Metals Train	3 tests at each condition	Gravimetric AA/ICAP
	Moisture	EPA Method 4[b]		Graviemtric
	Molecular Weight (O_2, CO_2, N_2)	EPA Method 3[b]		Orsat
	Velocity	EPA Method 1[b] and 2		Pitot Tubes/ Manometer
	HCl	EMSL HCl	3 tests at each condition	Ion Chromatography
	Toxic Metals Reagent Blank	EMSL Toxic Metals Train	1	ICAP/AA
	HCl Reagent Blank	EMSL HCl	1	Ion Chromatography

[a] ICAP = inductively coupled argon plasma spectrometer; AA = atomic absorption spectrometer.

[b] Velocity, moisture, and molecular weight will be determined from the metals sampling train.

[c] Metals: Pb, As, Hg, Sb - by atomic absorption spectrometer (AA)
Bi, Mg, Se, Cd, Be, Ag, Cr, Cu, Sr, Zn, Ni - by inductively coupled argon plasma spectrometer (ICAP)

TABLE 5-1. SAMPLING AND ANALYTICAL MATRIX (continued)

Sampling Location	Analytes Sampled	Sampling Method or Type	Number of Samples	Analytical Method[a]
Stack (Control Device Outlet)	Particulate Metals[d]	EMSL Toxic Metals Train	3 tests at each condition	Gravimetric AA/ICAP
	Moisture	EPA Method 4[b]		Graviemtric
	Molecular Weight (O_2, CO_2, N_2)	EPA Method 3[b]		Orsat
	Velocity	EPA Method 1[b] and 2		Pitot Tubes/ Manometer
	HCl	EMSL HCl	3 tests at each condition	Ion Chromatography
	Toxic Metals Reagent Blank	EMSL Toxic Metals Train	1	ICAP/AA
	HCl Reagent Blank	EMSL HCl	1	Ion Chromatography
Waste Feed	Metals[d]	Grab samples[c]	One sample for each manual test	AA/ICAP
Slag	Metals[d]	Grab samples[c]	One sample for each manual test	AA/ICAP
Spray Dryer/ Baghouse Catch	Metals[d]	Grab samples[c]	One sample for each manual test	AA/ICAP

---

[a] ICAP = inductively coupled argon plasma spectrometer; AA = atomic absorption spectrometer.

[b] Velocity, moisture, and molecular weight will be determined from the metals sampling train.

[c] Composite grab samples of the waste feed materials will be collected. All of these samples will be archived.

[d] Metals: Pb, As, Hg, Sb - by atomic absorption spectrometer (AA)
Bi, Mg, Se, Cd, Be, Ag, Cr, Cu, Sr, Zn, Ni - by inductively coupled argon plasma spectrometer (ICAP).

TABLE 5-1. SAMPLING AND ANALYTICAL MATRIX (continued)

Sampling Location	Analytes Sampled[c]	Sampling Method or Type[b]	Number of Samples	Analytical Method
Brine #1 Spray Dryer & Absorber Inlet	Metals	Grab samples	One sample for each manual test	AA/ICAP
Brine #2 Ionizing Wet Scrubber Recirculation #1	Metals	Grab samples	One sample prior to test; one at 15 min. during; one after.	ICAP/AA
Brine #3 Ionizing Wet Scrubber Recirculation #2	Metals	Grab samples	One sample prior to test; one at 15 min. during; one after.	ICAP/AA
Neutralization Tank Outlet	Metals	Grab samples	One sample prior to test; one at 15 min. during; one after.	ICAP/AA
Make-Up Water	Metals	Grab samples	One sample for each manual test	ICAP/AA
Cooling Tower Blowdown	Metals	Grab samples	One sample for each manual test	ICAP/AA
Ionizing Wet Scrubber Inlet #2	Metals	Grab samples	One sample for each manual test	ICAP/AA
Metals Surrogates (Metals Additives) (Effluent)	Metals	Grab samples	Two per test	ICAP/AA

[a] ICAP = inductively coupled argon plasma spectrometer; AA = atomic absorption spectrometer.

[b] Composite grab samples of the waste feed materials will be collected. All of these samples will be archived.

[c] Metals: Pb, As, Hg, Sb - by atomic absorption spectrometer (AA)
Bi, Mg, Se, Cd, Be, Ag, Cr, Cu, Sr, Zn, Ni - by inductively coupled argon plasma spectrometer (ICAP).

1mo/081

TABLE 5-2. TEST SCHEDULE

Test Date	Condition	Activity
4-23-89		Arrived on site. Set up all locations.
4-24-89	1	AM metals/particulate/HCl, Run 1
	1	PM metals/particulate/HCl, Run 2
4-25-89	1	AM metals/particulate/HCl, Run 3
	2	PM metals/particulate/HCl, Run 4
4-26-89	2	AM metals/particulate/HCl, Run 5
	2	PM metals/particulate/HCl, Run 6
4-27-89		Equipment teardown.

TABLE 5-3. PARTICULATE/METALS GLASSWARE CLEANING PROCEDURES

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot, soapy water (Alconox\).
2. Rinse with tap water (X3)[a].
3. Rinse with distilled, deionized water (X3).
4. Soak in 10 percent HNO_3 for 8 hours.
5. Rinse with distilled, deionized water (X3).
6. Rinse with acetone to dry.
7. Allow glassware to air dry in a contamination-free environment.
8. Cap glassware with paraffin film, rubber caps, or glass plugs.

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[a] X3 - Three times.

TABLE 5-4. SAMPLE RECOVERY COMPONENTS FOR THE PARTICULATE/METALS TRAIN

Component	Code	Item
Front Half		
1	PR-Acet	Acetone rinse of probe liner, nozzle and front half of filter housing using a nylon bristle brush with Teflon-handle.
2	PR-HNO_3	0.1N nitric acid rinses of probe liner, nozzle, and front half of filter housing.
3	F	Filter.
Back Half		
4	IR-1	Contents of impingers 1-3 and rinses with HNO_3/H_2O_2 solution.
5	IR-2	50 mL aliquot from IR-1.
6	IR-3	Contents and rinses of impinger number 4. Rinse with 4 percent HCl.

TABLE 5-5. SAMPLING METHOD, FREQUENCY OF SAMPLING AND PARAMETERS OF ANALYSIS FOR INFLUENT AND EFFLUENT STREAMS

Sample	Frequency/Run	Sampling Method	Analysis
Organic Liquid	1 sample per condition	S004	PCBs TOX BTU Total Metals
Aqueous Liquid	1 sample per day	S004	PCBs TOX BTU
Dirt/Soils/Debris	1 sample per drum	S007	PCBs TOX BTU Total Metals
Capacitors[a]			
Debris[b]			
Slag	15 minute intervals	S007	PCBs Total Metals
Brine	15 minute intervals	S004	PCBs Total Metals
Baghouse	4 thief samples per day	S007	PCBs Total Metals
Gas	refer to Section 4.1		

[a] Capacitors were not analyzed, rather their composition was determined by a literature search. Please refer to Table 3-4.

[b] Debris may come in any form, but typically consists of Tyvek suits, rubber gloves, floor-dry, and paper towels.

TABLE 5-6. ANALYTICAL PROCEDURES FOR WASTE FEED, SLAG, BAGHOUSE ASH AND BRINE STREAMS[a]

Parameter	Analysis Method	Reference
PCBs	8080	SW-846
BTU	D-240	ASTM
TOX	D-808	ASTM
Total Metals		
Ag	6010	SW-846
As	7060	SW-846
Ba	6010	SW-846
Be	6010	SW-846
Cd	6010	SW-846
Cr	6010	SW-846
Cu	6010	SW-846
Hg	7470	SW-846
Ni	6010	SW-846
Pb	7421	SW-846
Sb	6010c	SW-846
Se	6010	SW-846
Zn	6010	SW-846

[a] Analytical procedures for flue gas samples are discussed in Section 5.0.

TABLE 5-7. SUMMARY OF GAS SAMPLING PARAMETERS AND CONDITIONS FOR PARTICULATE/METALS SAMPLING AT CONDITION 1

TEST LOCATION	Afterburner Outlet			Baghouse Outlet			Scrubber Stack		
TEST DATE	4/25/89	4/25/89	4/26/89	4/25/89	4/25/89	4/26/89	4/25/89	4/25/89	4/26/89
TEST RUN NUMBER	1	2	3	1	2	3	1	2	3
TIME	10:49- 12:49	15:50- 17:50	11:30- 13:25	10:50- 13:30	15:50- 19:06	11:30- 14:05	10:51- 13:23	15:50- 19:13	11:30- 13:51
STACK TEMP. (F)	2270	2310	2250	422	424	422	141	152	148
OXYGEN (%V)	8.0	7.1	6.8	9.8	9.0	10.9	11.5	11.2	11.4
STACK MOISTURE (%V)	14.3	15.6	16.3	40.8	46.2	41.7	20.0	26.1	23.1
VOL. FLOW RATE (ACFM)	112,000	111,000	90,800	62,000	65,500	60,800	31,800	37,200	34,700
VOL. FLOW RATE (DSCFM)	18,100	17,400	14,400	21,000	20,100	20,300	21,600	23,000	22,500
PERCENT ISOKINETIC	NA	NA	NA	89.6	95.0	91.4	102	94.9	97.5

TABLE 5-8. SUMMARY OF GAS SAMPLING PARAMETERS AND CONDITIONS FOR PARTICULATE/METALS SAMPLING AT CONDITION 2

TEST LOCATION	Afterburner Outlet			Baghouse Outlet			Scrubber Stack		
TEST DATE	4/26/89	4/27/89	4/27/89	4/26/89	4/27/89	4/27/89	4/26/89	4/27/89	4/27/89
TEST RUN NUMBER	4	5	6	4	5	6	4	5	6
TIME	15:30-17:30	10:45-12:23	15:50-17:38	15:30-18:08	10:45-14:15	15:50-14:19	15:30-17:59	10:45-15:37	15:50-19:06
STACK TEMP. (F)	2300	2300	2400	423	422	422	150	152	152
OXYGEN (%V)	6.8	6.2	7.0	10.1	10.8	8.1	11.1	11.8	10.7
STACK MOISTURE (%V)	16.2	16.7	16.2	48.7	49.2	48.8	23.1	24.6	24.7
VOL. FLOW RATE (ACFM)	92,000	80,800	104,800	63,600	62,600	57,700	34,500	35,000	33,500
VOL. FLOW RATE (DSCFM)	14,300	12,500	15,600	18,600	18,200	16,900	22,300	22,000	21,000
PERCENT ISOKINETIC	NA	NA	NA	101	101	101	96.5	98.4	97.7

6.0 ANALYTICAL PROCEDURES

Laboratory activities for this program included analyses for particulate, metals, and chloride. Each of the methods is described briefly in the sections below.

6.1 Total Particulate Matter

The quantity of particulate matter recovered from both the rinse and the filter catches was determined gravimetrically using a 5-place analytical balance. Acetone rinses from the toxic metals trains were dried and desiccated for at least 24 hours and weighed to a constant weight.* Filters were placed in a desiccator for 24 hours and weighed to a constant weight as well. The resulting net rinse and filter weights were then summed and used to calculate grain-loading values.

6.2 Metals Analyses

Concentrations of lead, arsenic, mercury, antimony, and selenium were determined by SW-846 Methods 7421, 7060, 7470, 7041, and 7740, respectively. These analyses were performed by atomic absorption (AA) spectroscopy. The remaining metals analyses were completed using SW-846 Method 6010, which uses inductively coupled argon plasma (ICAP) techniques. ICAP analyses were completed for cadmium, chromium, barium, beryllium, bismuth, copper, magnesium, nickel, silver, strontium, and zinc. Figures 6-1a and 6-1b detail the digestion and analysis schemes used for the metals analyses.

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*"A deviation of less than either 0.5 mg or one percent of the total weight less tare weight, whichever is greater, between two consecutive weighings with no less than six hours of desiccation time between weighings."(1)

6.3 HCl Analysis

Concentrations of HCl were determined by analyzing the H_2SO_4 impinger solutions for chloride ions (Cl^-) concentration. This was accomplished using ion chromatography (IC). A multipoint calibration was completed both prior to and following injections of the samples in order to account for any instrument drift which may have occurred. Appropriate blanks, duplicates, and spiked samples were also be analyzed.

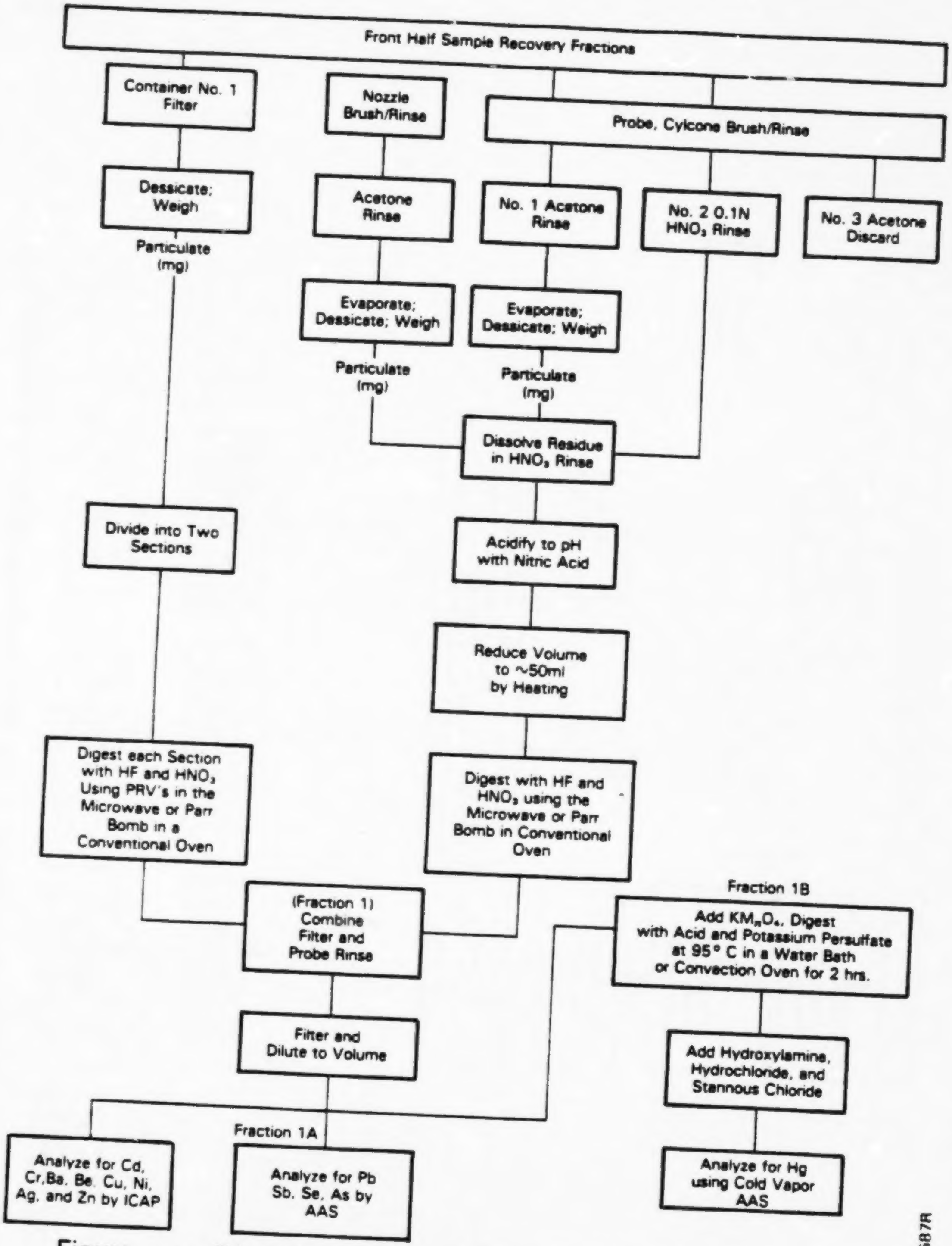
Front Half Sample Recovery Fractions
Container No. 1 Filter
Nozzle Brush/Rinse
Probe, Cylcone Brush/Rinse
Dessicate; Weigh
Particulate (mg)
Acetone Rinse
No. 1 Acetone Rinse
No. 2 0.1N HNO_3 Rinse
No. 3 Acetone Discard
Evaporate; Dessicate; Weigh
Particulate (mg)
Evaporate; Dessicate; Weigh
Particulate (mg)
Dissolve Residue in HNO_3 Rinse
Divide into Two Sections
Acidify to pH with Nitric Acid
Reduce Volume to ~50ml by Heating
Digest each Section with HF and HNO_3 Using PRV's in the Microwave or Parr Bomb in a Conventional Oven
Digest with HF and HNO_3 using the Microwave or Parr Bomb in Conventional Oven
Fraction 1B
(Fraction 1) Combine Filter and Probe Rinse
Add KM_nO_4, Digest with Acid and Potassium Persulfate at 95° C in a Water Bath or Convection Oven for 2 hrs.
Filter and Dilute to Volume
Add Hydroxylamine, Hydrochloride, and Stannous Chloride
Fraction 1A
Analyze for Cd, Cr,Ba, Be, Cu, Ni, Ag, and Zn by ICAP
Analyze for Pb Sb, Se, As by AAS
Analyze for Hg using Cold Vapor AAS

Figure 6-1a. Digestion and Analysis Scheme for Metal Train Components - Front Half

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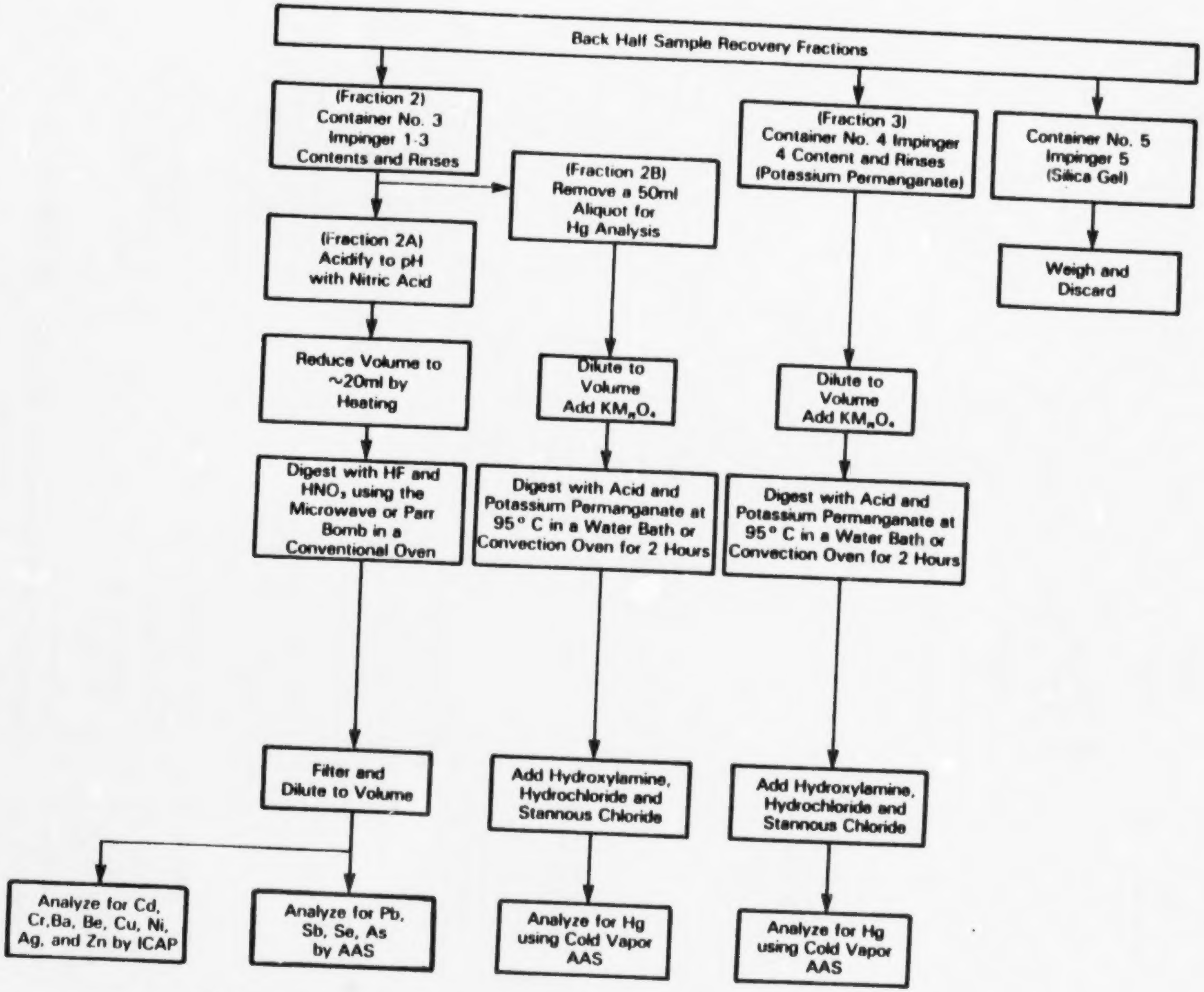
Back Half Sample Recovery Fractions
(Fraction 2) Container No. 3 Impinger 1-3 Contents and Rinses
(Fraction 2B) Remove a 50ml Aliquot for Hg Analysis
(Fraction 3) Container No. 4 Impinger 4 Content and Rinses (Potassium Permanganate)
Container No. 5 Impinger 5 (Silica Gel)
(Fraction 2A) Acidify to pH with Nitric Acid
Weigh and Discard
Reduce Volume to ~20ml by Heating
Dilute to Volume Add KM_nO_4
Dilute to Volume Add KM_nO_4
Digest with HF and HNO_3 using the Microwave or Parr Bomb in a Conventional Oven
Digest with Acid and Potassium Permanganate at 95° C in a Water Bath or Convection Oven for 2 Hours
Digest with Acid and Potassium Permanganate at 95° C in a Water Bath or Convection Oven for 2 Hours
Filter and Dilute to Volume
Add Hydroxylamine, Hydrochloride and Stannous Chloride
Add Hydroxylamine, Hydrochloride and Stannous Chloride
Analyze for Cd, Cr,Ba, Be, Cu, Ni, Ag, and Zn by ICAP
Analyze for Pb, Sb, Se, As by AAS
Analyze for Hg using Cold Vapor AAS
Analyze for Hg using Cold Vapor AAS

Figure 6-1b Digestion and Analysis Scheme for Trace Metal Train Components - Back Half

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

This section discusses the quality assurance and quality control (QA/QC) program implemented for the project and the results obtained from analyzing the QA/QC samples. The objective of the QA/QC program is briefly discussed in the section below. Summaries of QC data are presented in Section 7.2.

7.1 QA/QC Program Objectives

For any measurement effort there exists a degree of uncertainty due to the inherent limitations of the measurement system. The purpose of the QA program was to assess the magnitude of the degree of uncertainty in order to accurately assess the results obtained from these measurements. To meet this objective, the test plan was implemented and EPA reference methods or state-of-the-art sampling/analytical procedures for all critical measurements and QC activities were followed. The ultimate goal was to produce representative, complete, and comparable data of known quality.

The QA/QC program emphasized strict adherence to sampling and analytical procedures. The custody of the samples was monitored and the data were carefully documented. Sample matrices were spiked and spike duplicates analyzed to assess analytical method accuracy and precision. The QA/QC program provided a method for controlling data quality and to some extent the degree of uncertainty in the measurements system. The program also provided the basis for estimating the uncertainty by providing data for defining error limits.

7.2 Method-Specific QA/QC

The quality control procedures for front, and back-half impinger samples included:

- Adherence to approved methods;
- Equipment calibration;
- Glassware and equipment cleaning;
- Sample custody procedures; and
- The use of matrix spikes, matrix spike duplicates, reagent blanks, and method blanks.

Quality control procedures and results are presented in this section. Procedures generally applicable to all sampling methods are discussed in Section 7.2.1. Results from metals and HCl analyses are presented in Sections 7.2.2 and 7.2.3.

7.2.1 General Quality Assurance and Quality Control Procedures

Estimated precision, accuracy and data capture objectives for this test program are summarized in Table 7-1. These objectives are based EPA collaborative test results, as well as on Radian's recent experience with the specific analytical procedures.

The custody of the samples was monitored and considered crucial in assessing sample integrity since samples were collected in the field and analyzed in the laboratory. Samples were assigned unique identification numbers and integrity seals were affixed to sample containers. A master file of all samples collected was maintained and an informal log of daily activities was used to record other information concerning sampling activities.

Field equipment, including pitot tubes, nozzles, temperature measuring devices, and dry gas meters, were calibrated before and after field sampling as required by the sampling procedures used. Analytical balances were calibrated over the expected range of use with standard NBS weights. Daily calculations were made with QC weights previously checked with NBS traceable weights. All calibrations were documented on worksheets. Instruments used for atomic absorption (AA) and inductively coupled argon plasma

(ICAP) analyses were calibrated according to the procedures recommended in the specific methods.

All sample train glassware, containers and tools were cleaned to minimize potential for contamination. Cleaning procedures were specified in the test plan. Sample train glassware was capped after cleaning and immediately after each test. A clean environment was maintained for train assembly and recovery.

7.2.2 Particulate and Metal Sampling and Analysis

Sampling for particulate matter, toxic metals and surrogate metals was performed according to a modified version of EPA Method 5, entitled "Methodology for the Determination of Trace Metal Emissions in Exhaust Gases from Stationary Source Combustion Processes." The results of isokinetic sampling rate calculations are presented in Tables 7-2 and 7-3. Isokinetic sampling rates for all particulate/metals tests conducted at the scrubber stack and at the baghouse outlet met the QC objective of 100 ± 10 percent, with the exception of the baghouse outlet Run 01. The isokinetic sampling rate for this test run was 89.6 percent.

Leak checks were performed before and after each port change and each test run. All the particulate/metals sampling trains met the QA criteria of a leak rate less than or equal to 0.02 acfm. The leak rate data can be found on the field data sheets in Appendix C.1.

Analysis for metals was performed by either inductively coupled argon plasma (ICAP) or by atomic absorption (AA). Matrix spike, matrix spike duplicate, method blank and reagent blank results are presented in Tables 7-4 through 7-7. Previously analyzed field samples were spiked with known concentrations of the target metals to yield the matrix spike and matrix spike duplicates. The results from the analysis of these spikes provided information on analytical recovery and precision.

The QC objective for the metals analysis was ±30 percent recovery. Review of the data presented in Tables 7-4 and 7-5 shows excellent matrix spike recoveries for all of the target metals except mercury. Matrix spike recoveries for mercury are within the QC objective for three of the four matrix spikes analyzed. The recovery of mercury from the matrix spike duplicate for Impinger 4 was 56 percent (Table 7-5). The precision for the Impinger 4 matrix spikes is also outside the QC criterion of ±15 percent. The poor precision can be attributed to the low recovery obtained for the second analysis. The poor recovery for the Impinger 4 matrix spike duplicate suggests that flue gas mercury concentrations reported in Section 4.1 for some samples may be somewhat low.

The results reagent and method blank analyses are presented in Tables 7-6 and 7-7. Small amounts, within five times the detection limit, of Ag, As, Ba, Cd, Mn, Pb, and Sr were found in the reagent blank analyzed for the front half samples. These quantities were generally insignificant relative to amounts of these metals present on the samples. Analysis results for the field samples, however, were blank corrected for the quantity of metals found in the reagent blank. The method blank for the front half analysis was clean.

As shown in Table 7-7, three reagent blanks and a method blank analyzed with the back half samples were all clean with the exception of a small amount of lead and mercury in the reagent blanks. Concentrations reported in Section 4.1 were blank corrected.

7.2.3 HCl Sampling and Analysis

During HCl sampling, leak checks were also performed before and after each test run. All leak checks met the leak check QC criteria. Two matrix spike/matrix spike duplicates, a reagent blank, and a matrix blank were analyzed along with the HCl field samples. Chloride recoveries for the four matrix spikes were 96.3, 105, 96.2 and 96.2 percent, which is acceptable. The reagent blank and the laboratory blank were both clean, with chloride contents below the detectable level of 1 mg/L.

TABLE 6-1. SUMMARY OF ESTIMATED PRECISION, ACCURACY, AND DATA CAPTURE OBJECTIVES

Parameter (Method)	Precision	Accuracy	Data Capture[a]
Total Particulate (Toxic Metals Train)	± 11%[b]	± 10%[b]	90%
Flue Gas Metals	± 15%[c]	± 30%[d]	90%
Waste Feed Metals	± 15%[c]	± 30%[d]	90%
Velocity/Volumetric Flow Rate (EPA Method 1 and 2)	± 6%[b]	± 10%[b]	95%
Fixed Gases/Molecular Weight (Modified EPA Method 3)	± 10%[b]	± 20%[b]	90%
Moisture (EPA Method 4)	± 20%[b]	± 10%[b]	90%
Flue Gas Temperature (thermocouple)	± 2°F	± 5°F	90%
Hydrochloric Acid (HCl)	± 10%[c]	± 15%[d]	90%

[a] Percentage of valid data compared to total tests conducted.

[b] Precision and accuracy estimate based on results of EPA Collaborative tests.

[c] Coefficient of variation (CV) for duplicate analyses, where

$$\% \text{ CV} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

[d] Relative error (%) based on recovery of matrix spike analytes, where:

$$\% \text{ Relative Error} = \frac{\text{Measured Value} - \text{Spiked Value}}{\text{Spiked Value}} \times 100$$

TABLE 7-2. SUMMARY OF GAS SAMPLING PARAMETERS AND CONDITIONS FOR PARTICULATE/METALS SAMPLING AT CONDITION 1

TEST LOCATION	Afterburner Outlet			Baghouse Outlet			Scrubber Stack		
TEST DATE	4/25/89	4/25/89	4/26/89	4/25/89	4/25/89	4/26/89	4/25/89	4/25/89	4/26/89
TEST RUN NUMBER	1	2	3	1	2	3	1	2	3
TIME	10:49-12:49	15:50-17:50	11:30-13:25	10:50-13:30	15:50-19:06	11:30-14:05	10:51-13:23	15:50-19:13	11:30-13:51
STACK TEMP. (F)	2270	2310	2250	422	424	422	141	152	148
OXYGEN (%V)	8.0	7.1	6.8	9.8	9.0	10.9	11.5	11.2	11.4
STACK MOISTURE (%V)	14.3	15.6	16.3	40.8	46.2	41.7	20.0	26.1	23.1
VOL. FLOW RATE (ACFM)	112,000	111,000	90,800	62,000	65,500	60,800	31,800	37,200	34,700
VOL. FLOW RATE (DSCFM)	18,100	17,400	14,400	21,000	20,100	20,300	21,600	23,000	22,500
PERCENT ISOKINETIC	NA	NA	NA	89.6	95.0	91.4	102	94.9	97.5

TABLE 7-3. SUMMARY OF GAS SAMPLING PARAMETERS AND CONDITIONS FOR PARTICULATE/METALS SAMPLING AT CONDITION 2

TEST LOCATION	Afterburner Outlet			Baghouse Outlet			Scrubber Stack		
TEST DATE	4/26/89	4/27/89	4/27/89	4/26/89	4/27/89	4/27/89	4/26/89	4/27/89	4/27/89
TEST RUN NUMBER	4	5	6	4	5	6	4	5	6
TIME	15:30- 17:30	10:45- 12:23	15:50- 17:38	15:30- 18:08	10:45- 14:15	15:50- 14:19	15:30- 17:59	10:45- 15:37	15:50- 19:06
STACK TEMP. (F)	2300	2300	2400	423	422	422	150	152	152
OXYGEN (%V)	6.8	6.2	7.0	10.1	10.8	8.1	11.1	11.8	10.7
STACK MOISTURE (%V)	16.2	16.7	16.2	48.7	49.2	48.8	23.1	24.6	24.7
VOL. FLOW RATE (ACFM)	92,000	80,800	104,800	63,600	62,600	57,700	34,500	35,000	33,500
VOL. FLOW RATE (DSCFM)	14,300	12,500	15,600	18,600	18,200	16,900	22,300	22,000	21,000
PERCENT ISOKINETIC	NA	NA	NA	101	101	101	96.5	98.4	97.7